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Empire Building, Pittsburgh, Pennsylvania

IRON AND STEEL ENGINEER

AUGUST • 1940

VOL. XVII NO. VIII

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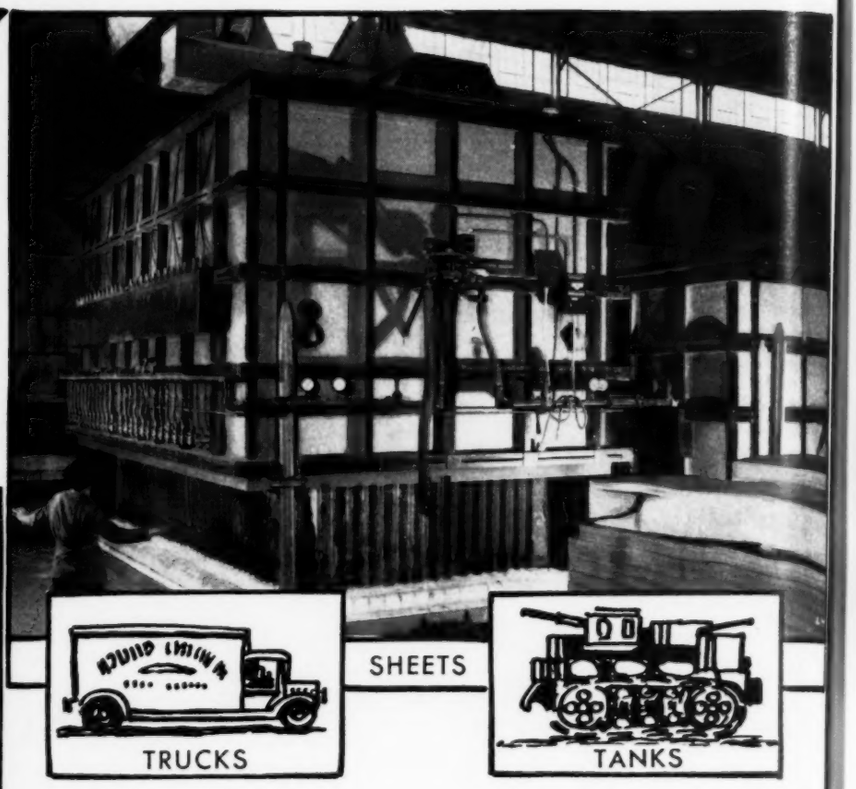

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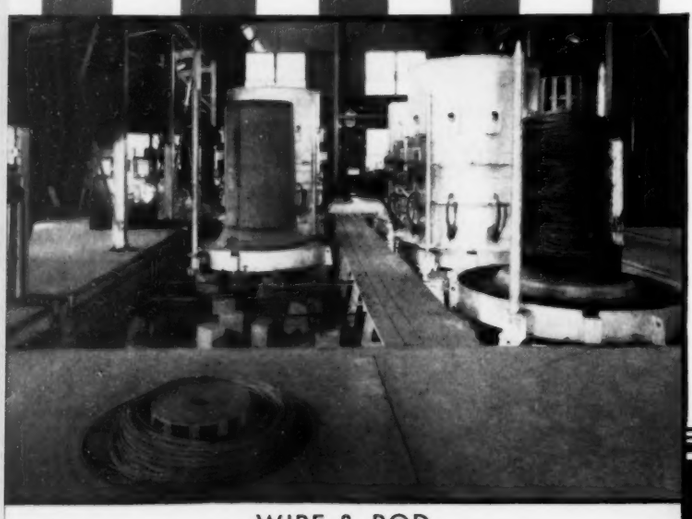

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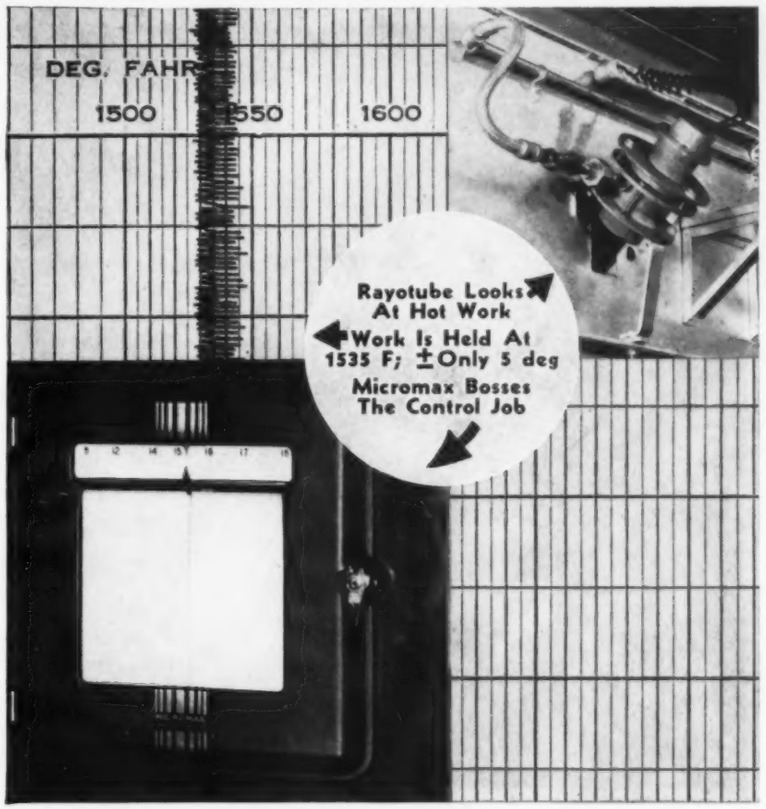
Temperature of ingot, billet, rod, plate, skelp, etc., is being recorded in many mills as the material is in motion. The Speedomax Recorder and Rayotube Detector employed are described in Bulletin N-33B-685(1) which will be sent on request.



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Open hearth production is generally stepped up when the burner air is reversed automatically by a Micromax pyrometer. See Bulletin 841 for details.

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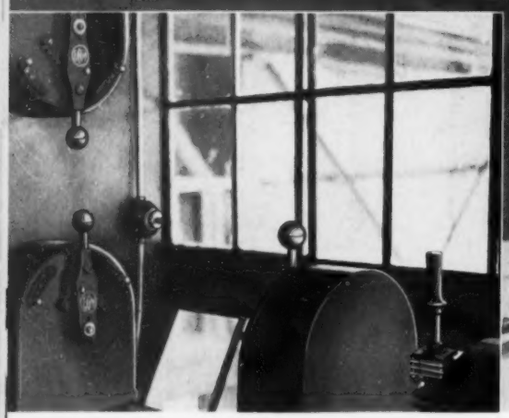
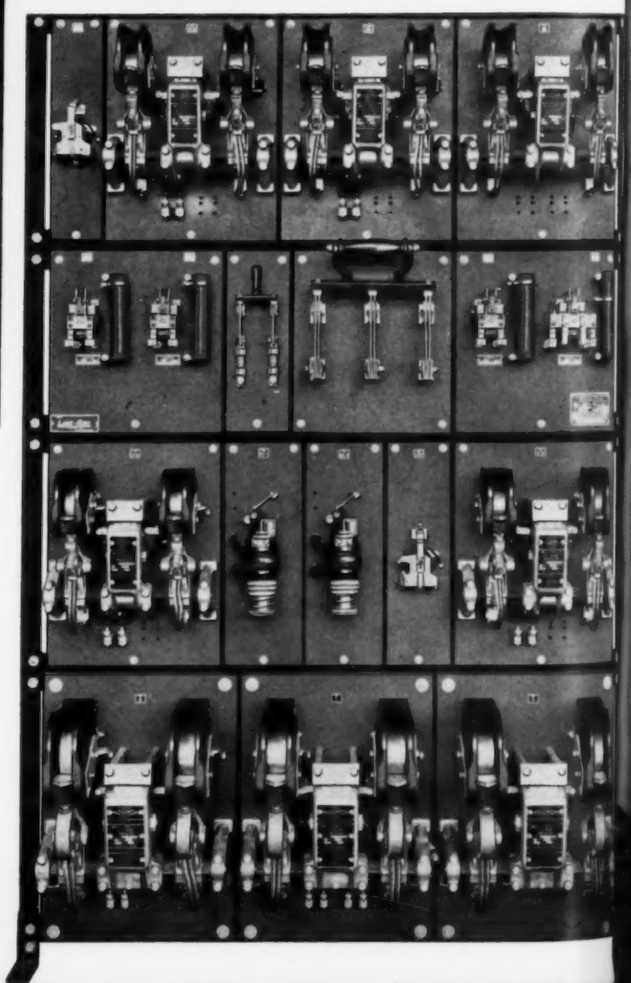


5½-Ton Cleveland Crane in cement plant in Ohio



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SEPTEMBER 24 - 25 - 26 - 27, 1940

Under one roof will be housed all the activities of the Convention and Exposition, thus affording ample opportunity for all to participate fully in all functions.

Tuesday, September 24

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—REGISTRATION

Chairman:
L. F. COFFIN
Mechanical Superintendent
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
A. R. DIBBEN
Electrical Department
Youngstown Sheet and Tube Company
East Chicago, Indiana

9:00 A.M.—LADIES' REGISTRATION

9:15 A.M.—BUSINESS SESSION

Chairman:
J. A. CLAUSS
Chief Engineer
Great Lakes Steel Corporation
Ecorse, Michigan

Vice-Chairman:
J. L. MILLER
Assistant Chief Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:30 A.M.—MECHANICAL ENGINEERING DIVISION

Chairman:
GEORGE H. ROSE
Chief Engineer
American Steel and Wire Company
Cleveland, Ohio

Vice-Chairman:
T. E. HUGHES
Maintenance Superintendent
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

"Design and Operation of Gear Drives" by F. P. Dahlstrom, *Mechanical Engineer,* Farrel-Birmingham Company, Ansonia, Connecticut.

"Maintenance Shops in the Steel Plant" by T. R. Moxley, *General Master Mechanic,* Wheeling Steel Corporation, Steubenville, Ohio.

"Diesel Shifting Equipment in the Steel Plant" by E. M. Smith, *Assistant Sales Manager,* Electromotive Corporation, LaGrange, Illinois.

1:30 P.M.—ELECTRICAL ENGINEERING DIVISION

Chairman:
I. N. TULL
Electrical Superintendent
Republic Steel Corporation
Cleveland, Ohio

Vice-Chairman:
H. W. NEBLETT
Development and New Design Engineer
Inland Steel Company
East Chicago, Indiana

"Tentative Report of A.I.S.E. Crane Specification Committee by F. W. Cramer, *Chairman,* and I. E. Madsen, *Research Engineer.*

"Modern Electric Furnace Design and Practice" by H. F. Walther, *Assistant Melting Superintendent,* Steel and Tube Division, Timken Roller Bearing Company, Canton, Ohio.

"Mercury Arc Rectifiers for Main Roll Drives" by L. A. Umansky, Mining and Steel Mill Section, Industrial Department, General Electric Company, Schenectady, New York.

1:30 P.M.—WELDING ENGINEERING DIVISION

Chairman:
L. J. GOULD
Assistant Chief Engineer of Construction
Bethlehem Steel Company
Bethlehem, Pennsylvania

Vice-Chairman:
A. W. STEED
Maintenance Superintendent
American Rolling Mill Company
Middletown, Ohio

"Welded Construction of Blast Furnace Stoves" by H. C. Boardman, Chicago Bridge and Iron Company, Chicago, Illinois.

"Welded Open Hearth Auxiliaries" by C. C. Keyser, *Welding Supervisor,* Bethlehem Steel Company, Steelton, Pennsylvania.

"Building Up and Hard Surfacing" by L. Ames, Air Reduction Sales Company, New York, New York.

2:00 P.M.—LADIES' SIGHT-SEEING TRIP AND TEA

10:00 P.M.—EXHIBITORS' DANCE

Wednesday, September 25

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—COMBUSTION ENGINEERING DIVISION

Chairman:
H. T. WATTS
Combustion Engineer
Republic Steel Corporation
Gadsden, Alabama

Vice-Chairman:
E. J. WAGAR
Assistant Chief Engineer
Otis Steel Company
Cleveland, Ohio

"Effect of Pit Operation on Steel Conditioning" by Charles Labeka, Metallurgical Department, Pittsburgh Steel Company, Monessen, Pennsylvania.

"The Comparison of Soaking Pit Designs" by F. E. Leahy, *Superintendent of Fuel Department,* Youngstown Sheet and Tube Company, Youngstown, Ohio.

"Soaking Pit Control" by M. J. Boho, *Sales Engineer,* Hagan Corporation, Pittsburgh, Pennsylvania.

9:00 A.M.—OPERATING PRACTICE DIVISION

Chairman:
H. G. R. BENNETT, *Engineer*
Hot Rolling Mill
Carnegie-Illinois Steel Corporation
Pittsburgh, Pennsylvania

Vice-Chairman:
J. D. JONES
Chief Engineer
Youngstown Sheet and Tube Company
Youngstown, Ohio

"Composition Bearings for Roll Necks" by H. R. Gilchrist, *Lubrication Engineer,* Carnegie-Illinois Steel Corporation, Youngstown, Ohio.

"Hot Scarfing of Billets, Blooms and Slabs" by E. A. Doyle, *Consulting Engineer,* Linde Air Products Company, New York, New York.

"Design and Operation of Continuous Butt Weld Pipe

Mills" by J. H. Loux, *Electrical Engineer,* and E. T. Trebilcock, *Assistant Electrical Engineer,* Salem Engineering Company, Salem, Ohio.

11:00 A.M.—LADIES' LUNCHEON AND CARD PARTY

12:45 P.M.—INSPECTION TRIP: Youngstown Sheet and Tube Company, Indiana Harbor, Indiana.

Thursday, September 26

Iron and Steel Exposition—9:00 A.M.–5:30 P.M.

9:00 A.M.—ELECTRICAL ENGINEERING DIVISION

Chairman:
F. O. SCHNURE
Electrical Superintendent
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
G. R. CARROLL
Assistant Superintendent of Maintenance
Jones and Laughlin Steel Corporation
Aliquippa, Pennsylvania

"Reversing Drives for Slabbing Mills" by F. R. Burt, Engineering Department, Metal Working Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Power Requirements for Hot Strip Mills" by W. M. Ballenger, *Steel Mill Engineer,* General Electric Company, Chicago District, and T. R. Rhea, *Steel Mill Engineer,* General Electric Company, Schenectady, New York.

"Hot Strip Coilers and Their Drives" by R. A. Geuder, *Application Engineer,* Reliance Electric and Engineering Company, Cleveland, Ohio.

9:00 A.M.—COMBUSTION ENGINEERING DIVISION

Chairman:
M. J. CONWAY
Special Engineer
Lukens Steel Company
Coatesville, Pennsylvania

Vice-Chairman:
G. M. COUGHLIN
Combustion Engineer
American Rolling Mill Company
Ashland, Kentucky

"A Survey of Open Hearth Furnace Design" by W. C. Buell, Jr., *Consulting Engineer,* Cleveland, Ohio.

"Relation of Flame Characteristics to Open Hearth Operation" by A. J. Fisher, *Fuel Engineer,* Bethlehem Steel Company, Sparrows Point, Maryland.

"Open Hearth Furnace Control" by M. J. Bradley, *Engineer,* Leeds and Northrup Company, Philadelphia, Pennsylvania.

1:30 P.M.—OPERATING PRACTICE DIVISION

Chairman:
ALBERT W. VINCENT
Assistant Superintendent of Blast Furnaces
Carnegie-Illinois Steel Corporation
Gary, Indiana

Vice-Chairman:
C. P. BETZ
Assistant Manager, Hanna Furnace Division
Great Lakes Steel Corporation
Ecorse, Michigan

"Developments in Blast Furnace Gas Cleaning" by C. H. Glaser, *Superintendent* of Blast Furnaces, Carnegie-Illinois Steel Corporation, Youngstown, Ohio.

"Rehabilitation of Blast Furnaces" by J. H. Slater, *Assistant District Manager,* Republic Steel Corporation, Cleveland, Ohio.

"Factors Affecting Production of Blast Furnace Gas" by J. S. Fulton, *Special Representative,* Ingersoll-Rand Co., Pittsburgh, Pennsylvania.

1:30 P.M.—LUBRICATION ENGINEERING DIVISION

Chairman:
F. J. THOMAS
Lubrication Engineer
Republic Steel Corporation
Cleveland, Ohio

Vice-Chairman:
H. H. SHAKELY
General Master Mechanic
Jones and Laughlin Steel Corporation
Hot and Cold Strip Mills
Pittsburgh, Pennsylvania

"Manufacture and Composition of Grease Lubricants" by Thomas Lennox, Socony-Vacuum Oil Corporation, Trenton, Michigan.

"Lubrication and Its Relation to Maintenance" by C. W. Phillips, *General Master Mechanic,* and R. A. Barta, *Lubrication Engineer,* Republic Steel Corporation, Cleveland, Ohio.

"Application and Care of Bearings in Steel Plant Auxiliaries" by F. L. Gray, *Lubrication Engineer,* Carnegie-Illinois Steel Corporation, Gary Works, Gary, Indiana.

7:30 P.M.—FORMAL BANQUET AND DANCE

Friday, September 27

Iron and Steel Exposition—9:00 A.M.–12:00 Noon

9:00 A.M.—INSPECTION TRIP: Wisconsin Steel Works, International Harvester Company, Chicago, Illinois.

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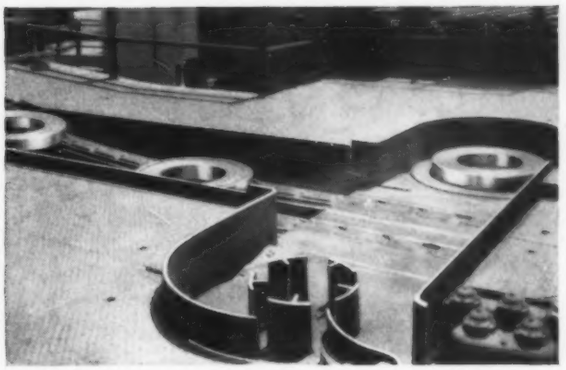
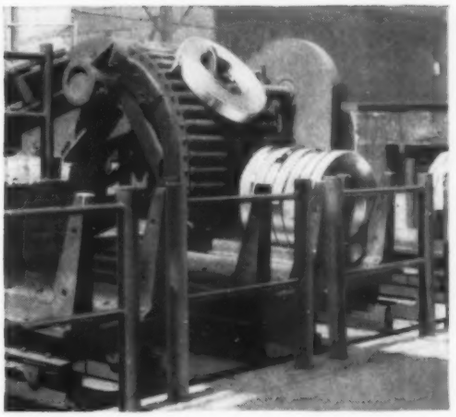
Utilizing 30,000 sq. ft. of space, the exhibits offer a complete cross-section of the engineering applications in the industry and will prove of universal appeal to those who desire to keep abreast of the new improvements. The Exposition will be held in the Hotel Stevens, in close proximity to the technical sessions and other activities of the Convention. This placing of all activities under one roof facilitates complete participation in all Convention activities.

EXPOSITION HOURS

TUESDAY, SEPT. 24—9:00 A. M. to 10:00 P. M.
WEDNESDAY, SEPT. 25—9:00 A. M. to 10:00 P. M.
THURSDAY, SEPT. 26—9:00 A. M. to 5:30 P. M.
FRIDAY, SEPT. 27—9:00 A. M. to 12:00 Noon.

View of Exposition in Chicago, 1937





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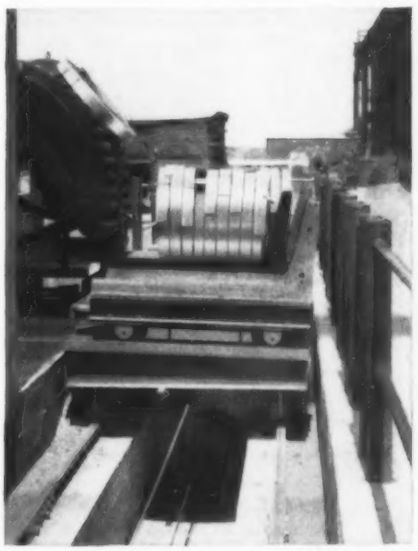

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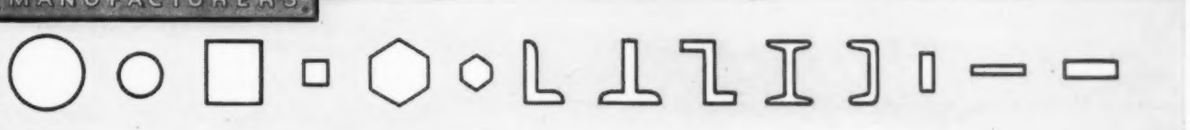


Strip Plant FINISHING EQUIPMENT

By D. A. McARTHUR, *Chief Engineer*

WEAN ENGINEERING COMPANY

WARREN, OHIO

PRESENTED BEFORE A. I. S. E. SPRING CONFERENCE, CINCINNATI, OHIO, APRIL 1 AND 2, 1940

▲ "STRIP Plant Finishing Equipment" is a very broad subject and would allow a great variety of papers, all of which could properly carry the title.

Since the title is so broad, it was decided that probably it would be of interest to give a very broad discussion of the whole subject and to try, in some manner, to assemble the principal operations carried on in the finishing department of a strip mill.

Strip mill finishing can broadly be divided into three departments:

1. Tin plate
2. Cold reduced sheet and strip
3. Hot rolled sheet and strip

Only a few strip mills have all of these departments in one plant, and even when this is the case, all three departments are usually under separate supervision. However, the work done on the material is fundamentally the same in all three. The continuous pickling department, because it is common to both sheet and tin cold reduction departments and because of its importance, can almost be considered a department in itself.

The simplest of these departments to describe is the first one. The great bulk of the material finished in a strip mill tin plate finishing department is shipped as sheared-to-size tin plate in exactly the same form as tin plate has been shipped for many years. A small percentage of the material processed in this department is for specialties such as "stove pipe blue," "enameling stock," "short ternes," etc. The percentage of this latter is, however, so small that the finishing process and the equipment in tin plate finishing departments is very much more standardized than in the other two departments. In some plants these specialties may be produced in the cold reduced sheet department rather than in the tin plate department.

All material of such gauge or quality that it must be cold reduced, with the exception, of course, of tin plate, passes through the cold reduced sheet department. This includes practically all auto body sheets, as well as a great multitude of other grades of material. In fact, practically everything that was formerly made in an old style sheet mill is now made in cold reduced sheet finishing departments, in addition to products peculiar to a strip mill such as material shipped in coil form.

The material finished in a hot rolled strip finishing department includes all material of such gauge or quality that cold reduction is unnecessary. Gauges are usually 18 gauge or heavier and, in general, the quality of the material is not as high and the price is not as great as for material passed through the cold reduced department.

As mentioned previously, the work done on the strip in each of these departments is fundamentally much the same and for convenience in the discussion, I have divided it into the following categories: (1) shearing; (2) heat treating; (3) flattening; (4) coating; (5) temper rolling; (6) miscellaneous surface preparations.

One of the above; *i.e.*, temper rolling, is in some respects often considered as not a part of a finishing department inasmuch as mills almost identical in design and operation to reducing mills are used; whereas, for all the other operations mentioned, special finishing equipment is used. However, the reason for temper rolling is considerably different than the reason for cold reducing and the operation is properly parallel to the others mentioned and, especially, is parallel to heat treating.

There are, of course, many sub-divisions of each one of the operations mentioned. Shearing includes side trimming, slitting, cutting up coils into pieces, and re-squaring.

Heat treating includes box annealing in sheet or coil form, open or blue annealing, normalizing, and single strand annealing.

Flattening may be done on roller levelers, stretcher levelers and, as a sub-division of temper rolling, on the temper mill.

Coating usually includes tinning, galvanizing and terne plating.

D. A. McARTHUR

Miscellaneous surface preparations include pickling, scrubbing, oiling, cleaning, grit blasting, and probably many others. Deoxidizing and annealing for a particular color properly come under heat treating, but are also a part of surface preparations, as in rolling on temper mills with especially surfaced rolls.

This outline has been given to emphasize the large number of operations involved in the strip mill finishing department. Normally a very large portion of the building area of a strip mill is occupied by these finishing operations. It is very interesting to observe the extreme variation in area used by different plants to process approximately the same tonnage of material. I presume that in half of the strip mills now in operation this area was determined more by available space and sometimes by available money rather than by accurate engineering calculations of the most desirable amount of space from every standpoint.

There are plants in operation with wide aisles, giving easy access to tractors and trucks to haul materials, and having plenty of storage space so that very little piling of orders on top of each other is necessary, and material never has to be picked up to be moved to the next operation. On the other hand, there are plants where material must be piled as high as can safely be done, and where a lift from one process cannot be set down until another lift going to some other process is picked up, and where, if tonnage approximately the same as produced in one day is not shipped that day, it would be almost impossible to process anything on the following day.

Obviously, any operator would choose the department with a large amount of space if he had the choice, but those without the available space have shown a surprising amount of ingenuity and energy in producing quality material at a good cost with the space they have available. It would be interesting if figures were available, as of course they are not, to have someone make a detailed study of exactly how much expenditure for building and floor space can be justified by the actual decrease in operating cost resulting from more spacious working conditions and less handling of the material.

At this point I wish to call your attention to a chart which I have prepared, outlining the different operations under discussion. You will note at the left hand side the finishing stands of the hot strip mill. Two types of material are delivered from the hot strip mill: first, hot rolled strip in coils; and second, hot rolled strip in cut pieces approximately 20 or 30 ft. long.

All material going to the tin plate department and the cold reduced sheet department is in coils, and probably over half of the material going to the hot strip finishing department is in coils. Usually, only material of such gauge that it is difficult to coil and process in coil form is cut on the hot strip mill, and I believe that the tendency is to produce more and more material in coil form.

The coils go to one of two places, either directly to the hot strip finishing department or to the continuous pickler.

Because of the large tonnage passing through it, the pickling department is one of the most important in the strip mill. All material to be cold reduced, either for sheet or tin plate, is at present pickled, and probably over 95 per cent of this tonnage goes through a continuous pickling unit very similar in design to that shown on this outline.

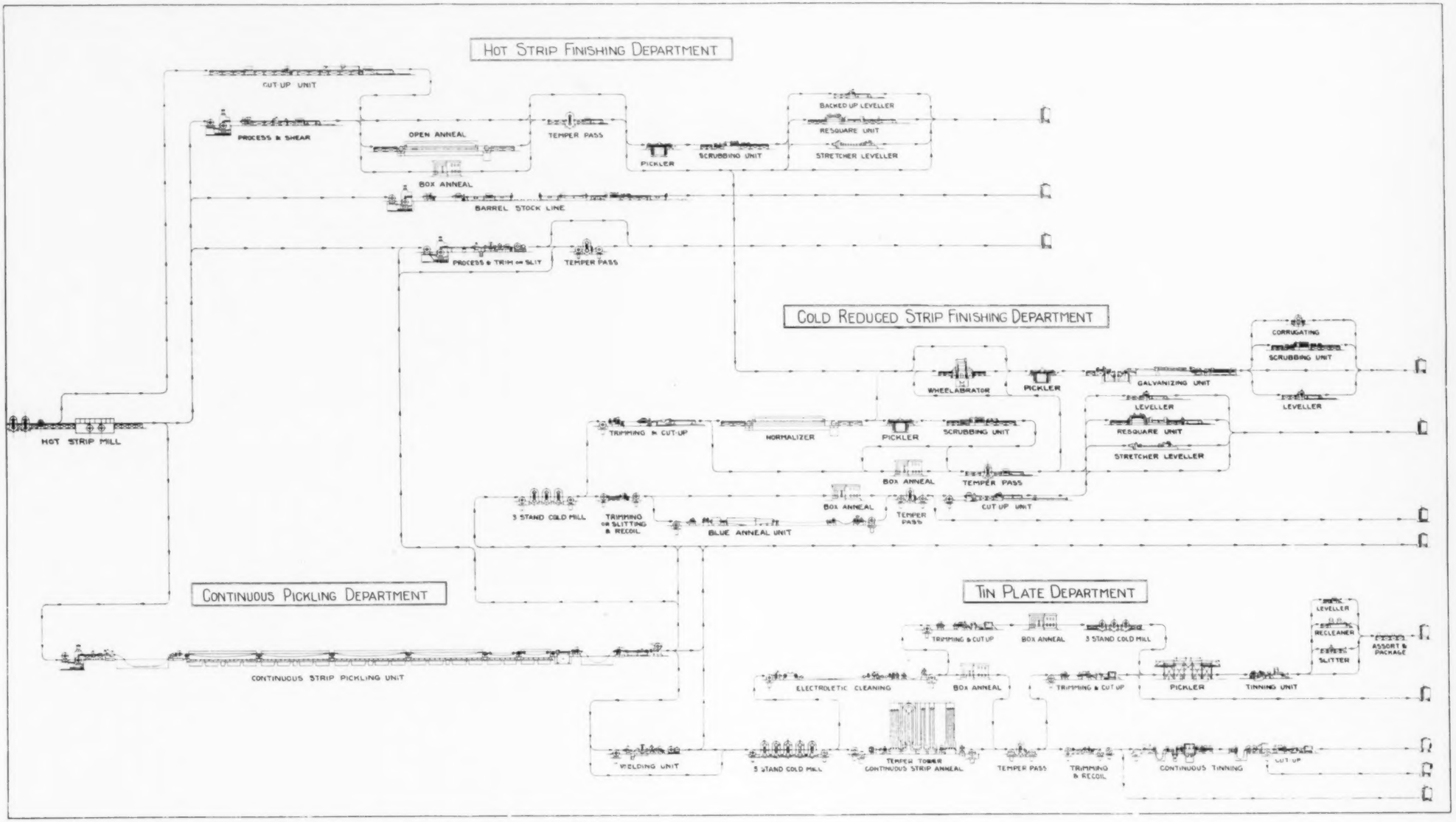
In the early development of cold reduced strip, several attempts were made to cold reduce strip without removing the scale in any way. All of these attempts have proven unsatisfactory inasmuch as the cost of the cold reduction was increased considerably more than the money saved by not pickling.

One satisfactory attempt to eliminate pickling operated for considerably over a year, but has since been abandoned. This was the use of centrifugally thrown abrasive by means of a revolving unit to remove the scale. This removed the scale and prepared the strip for satisfactory cold reduction. Although this operation has since been abandoned in favor of the more conventional pickling, it shows that the elimination of pickling is possible if processes are encountered in the future which render any contact with acid undesirable.

From the continuous pickler practically all the material goes either to the tin reduction mill or to the sheet reduction mill, although a small portion of it may be returned to the hot strip finishing department where it is either prepared for shipment in the coil as received from the pickler, or is side trimmed, sheared, temper rolled, or otherwise treated for shipment as pickled hot rolled strip.

In connection with continuous pickling, the material may be welded. You will note we have shown a welding unit separately for a certain portion of the material after continuous pickling. It seems that the tendency at present is to locate welding in a separate line at this point, and there are certainly advantages to this arrangement.

At present welding is done in any one of three places: before pickling, as a part of the pickle line, and sepa-



This diagram shows schematically the flow of material from the hot strip mill through subsequent finishing processes. Various combinations of processes may be used, including some perhaps not shown on the chart, which, however, portrays the principal processes.

rately after pickling. The advantage of doing it in the pickle line is obviously that of reducing the number of separate operations. The disadvantage is the necessary limitation in production of the pickle line when relatively short coils are being welded.

The advantages of welding after the pickle line are that somewhat better welds can be made on pickled strip and that a simple type of uncoiling device or feed reel can be used since the strip has been uncoiled previously through a processing uncoiler in the pickle line.

The only advantages of welding before pickling are that longer coils and therefore less joints are run through the pickle line and that the weld itself is pickled. Both of these are minor if, indeed, they are any advantage at all.

We will now follow through the tin plate department and will not pause to discuss in any way the cold reduction mill, as that is properly a rolling operation rather than a finishing operation. After the mill, by far the greatest percentage of material at present is passed through an electrolytic cleaning unit, which removes oil that may be left on the strip from the mill.

After cleaning, the strip is box annealed in cover type furnaces, where heat is applied from radiant tubes in the sides of the furnace. With this style of furnace, approximately three bases are provided for each furnace, and the coils are piled two or three high on the bases. An inner cover is then lowered into position over the coils and the outer cover or heating furnace is placed over the inner cover. Sometimes fans are installed under each pile of coils to circulate the air around the coils and to assist in rapid heating.

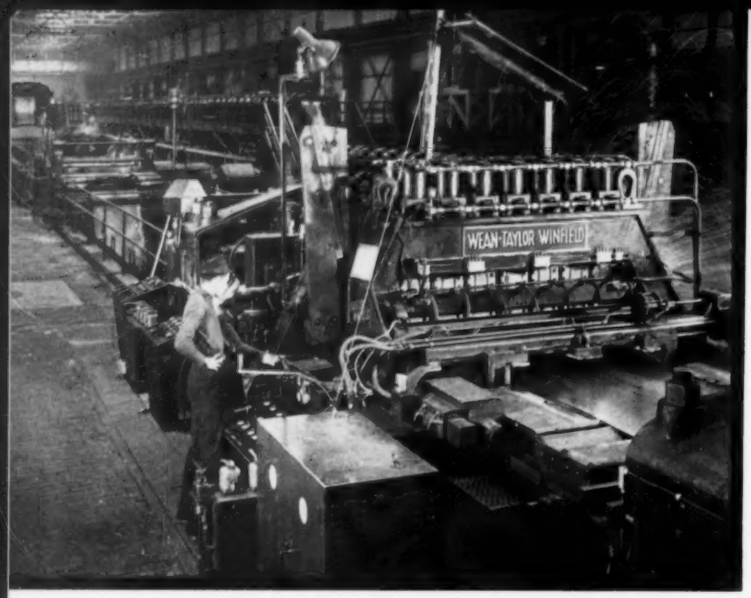
At present one tin plate producer has eliminated the cleaning operation by replacing the box annealing with temper tower continuous strip annealing, which is shown as a parallel operation on the chart. In this process, the coil is uncoiled, welded or stitched together the same as in an electrolytic cleaning unit, and then passed continuously through a vertical annealing furnace and vertical cooling chutes. Loopers are provided on each side to allow for continuous passage of the material through the furnace and cooling chambers while joints are being made and cut out. Strip is coiled on the other end the same as from the electrolytic cleaner.

Since there is no place on the strip for the products of combustion to deposit when the oil is burned off, cleaning before annealing has been found unnecessary when using this type of annealing. Besides eliminating completely the electrolytic cleaning, the obvious advantages of the temper tower continuous strip anneal are:

1. Accurate control of temper desired
2. Absolute uniformity from end to end of coil
3. A quick operation—the total cycle taking only about one hour in place of the 24 to 48 hours required for box annealing
4. The possibility of reducing considerably the present difficulties with temper passing

After either continuous strip annealing or box annealing in coil form, the material is temper passed on a

Pickling is one of the most important processes in the strip mill, due to the great tonnage passing through before cold reduction.



Welding, to obtain larger coils, may be done separately either before or after pickling, or as shown here, as part of the pickle line.

4-high mill. Since this is primarily a rolling operation, we will not discuss it any further, although it has been one of the most expensive and troublesome operations in the strip mill.

After temper passing, the great bulk of the material is cut up on a flying shear line which includes a side trimmer for trimming the edges and a flying shear for cutting the strip into tin plate sizes. After leaving the flying shear, the material is classified, the good material falling into one pile and off-gauge material or material with pinholes being piled in another pile.

At present, a small percentage of production, instead of being cut up at this point, is passed through a continuous electrolytic tinning unit, and after tinning is either cut up or coiled in the tinned form. While the tonnage thus being tinned is at present negligible, it is quite possible that a very considerable proportion of tin plate production may be made in this manner in future years. It is also quite possible that continuous strip hot dip tinning will be developed. Considerable work has been done on this to date, although no commercial lines are in operation except on very narrow strip.

Material that is to be coated in strip form and certain material that is to be shipped uncoated in strip form is usually run through a side trimming or slitting line. This consists of a coil holder, rotary slitting shear, and one or more reels. Where side trimming only is done, one reel is used. Where coils are to be slit into multiples, two reels are often used to eliminate the fanning of the strip which results from the spacers placed between coils when they are all wound onto one reel.

You will note one variation from the above-described process. In certain plants, the material is taken from the electrolytic cleaning line and cut up in tin plate sizes, then box annealed in this form and temper passed on old style 3-stand tandem tin plate cold mills. The tonnage receiving this process has been continually decreasing and probably will reach the vanishing point within a few years.

All the material to be tinned, except that to be continuously tinned, is then white pickled in sulphuric acid and run through tinning equipment, which may be of either the right angle or straight-away type. After tinning, material is assorted and packed for shipping, although some of it may be leveled, re-cleaned or slit.

This briefly covers the tin plate finishing department.

The pickled coils which are to go to the sheet mill finishing department go to the sheet cold reduction mill, where they are reduced to the proper gauge.

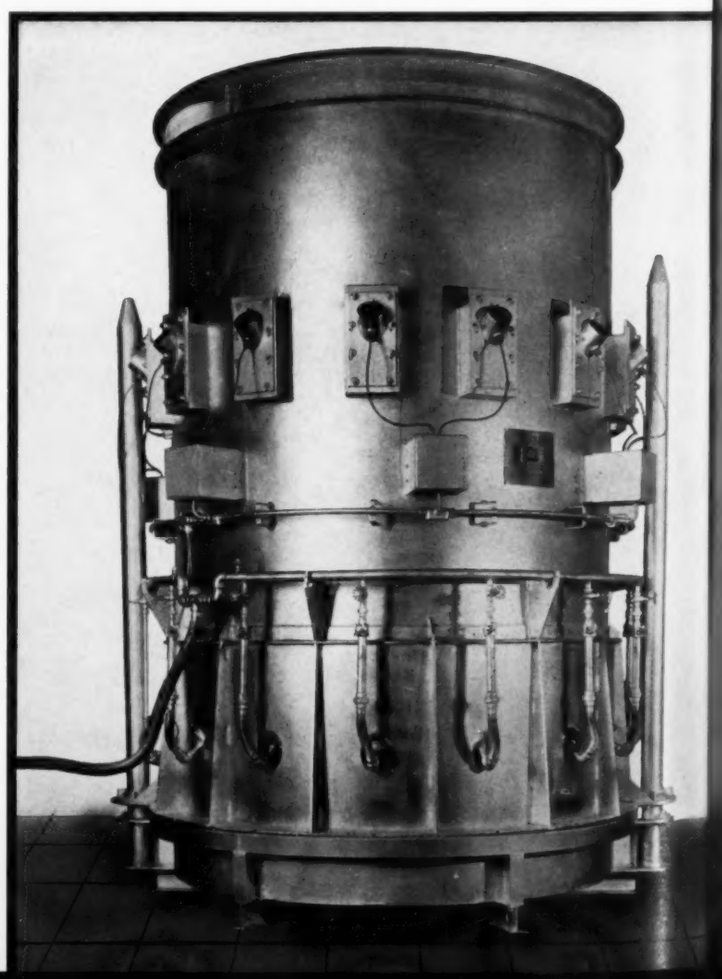
From there they go to the shearing line where the material is either cut to proper size or is side trimmed and recoiled.

The sheet or coil is then annealed, the largest percentage being box annealed in furnaces similar to that described under the tin mill process. A certain portion of the material is normalized or open annealed in a continuous furnace. At present only the cut sheet material receives this normalizing or open annealing, although it is quite possible that continuous strand furnaces for sheet mill products, as described for tin mill products, may be in use in the near future.

Material box annealed either in sheet or coil form is temper passed, this being done on identical mills except for the fact that the material in coil form is run on reels, whereas the material in sheet form is run through a mill without reels, and is afterward roller leveled.

The material normalized or open annealed is usually, but not always, pickled and scrubbed and dried after

Portable annealing covers, heated by radiant tubes, are used to process a large proportion of the strip mill production.



The temper tower continuous strip annealer has been used to replace electrolytic cleaning and box annealing in one tinplate plant.

annealing. After this, it may also be temper passed in the same mill as the box annealed sheet product.

A certain portion of the material annealed and temper passed in coils is also cut up into sheet form. The temper passed coils are usually prepared for shipment immediately after temper passing, whereas all the other material can go through numerous other processes such as roller leveling, stretcher leveling, re-squaring, oiling, or other processes, and it is then inspected and packaged for shipment.

A certain portion of this material which may come from any one of the early processes is galvanized. Before galvanizing, this material is always pickled in sulphuric acid, which often contains various additive agents to assist in obtaining a satisfactory sheet for coating; and a certain percentage of it is subjected to an abrasive blast in a revolving unit. On culvert stock in particular, this has proven a very great advantage.

Galvanizing equipment has recently received a great deal of attention from strip mill operating men, and considerable improvement has been made.

After galvanizing, the material may be specially roller leveled in 4-high roller levelers, corrugated, or formed into numerous other shapes, or may be shipped as flat galvanized material.

In galvanized material we also include various forms of non-spangled, zinc coated materials which have special trade names, and are usually protected by patents.

Although very little strip is at present terne coated, it is quite likely that in the future a considerable tonnage of long ternes will be made from strip mill products.

You will note that material coming from the hot strip mill finishing department may also be galvanized.

We will now go back to the hot strip mill finishing department, which receives mostly material which has not passed through the continuous pickler, although as mentioned before a certain amount of the continuous pickled material may be shipped in that form. Material to be shipped in coil form may be run through a line and welded for shipment to the customer as large coils. These coils are also often side trimmed or slit and recoiled, and may or may not be temper passed in coil form before shipment to the customer.

Most of the coils from the hot strip mill which are not continuous pickled go to a shearing line consisting of a processing uncoiler, side trimming shear, and either a flying shear or guillotine shear with gauger table, where they are cut up into the proper size for the customer's requirements.

One interesting variation of this shearing line is the so-called barrel stock line, where material is completely processed on one line and made ready for shipment. This usually consists of a processing uncoiler, a flying shear or guillotine shear with gauger table, roller leveler, a re-squaring unit usually consisting of side trimming shears and two guillotine end shears, and a scrubbing and drying unit placed in a continuous line. The material is piled at the end of this line and immediately packed and shipped to the barrel manufacturers.

Much of the material, after it has been processed, uncoiled and cut up, is temper passed and roller leveled. It then may or may not be pickled, scrubbed and dried, and stretcher leveled, re-squared or specially roller leveled. Variations in this procedure are almost infinite.

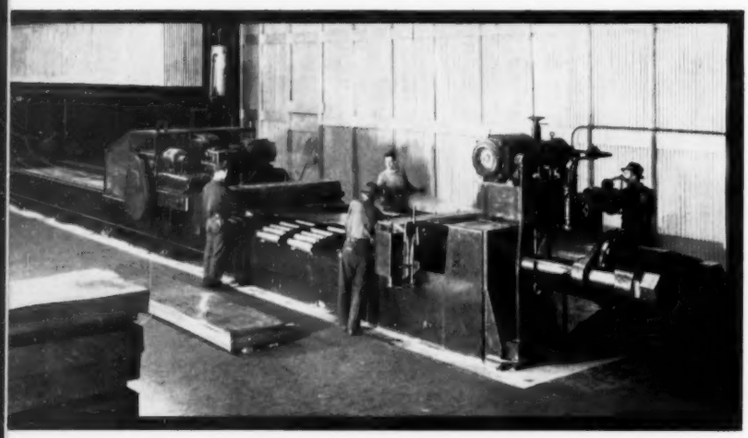
We will now go back to the 20 or 30-ft. pieces delivered from the hot strip mill. These are processed in a heavy gauge cutting-up line in the hot strip mill finishing department, which usually consists of a feeding table, a roller leveler, a side trimming and slitting shear, usually another roller leveler, and a guillotine cutting-up shear, or perhaps multiple guillotine cutting-up shears. This line cuts the material to the size required by the customer.

This material then follows through exactly the same operation as the hot mill material which has been cut up from coils, and is subject to the same variations in practice.

I do not claim at all that this chart and description show all the possible processes through which strip may pass in strip mill finishing departments, but I do believe they cover the principal ones. I wish to point out particularly that to a great extent in the cold reduced sheet department and to a very large extent in the hot rolled strip department the possible combination of operations becomes very large, and the customers' requirements change from day to day, making any

This tinplate shearing line includes a hydraulic cone type coil holder, flying micrometer, pinhole detector, rotary flying shear with leveling stand, classifier, and piler.

This sheet shearing unit is composed of a hydraulic cone type coil holder, side trimmer, scrap chopper, flying shear, belt conveyor, and piler.



Stretcher leveling, performed in a unit as here shown, may form a final step in the processing of hot rolled material.

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Many small improvements have been made on the equipment used for tinning, resulting in a better quality of product.

dogmatic statement as to exact sequence of processes entirely impossible.

We have covered fairly thoroughly in a rather hurried time what is done to strip in a strip mill finishing department. It will be interesting to spend a little time on the discussion of how well it is done now as compared to only a few short years ago when strip mills began to come into operation. In almost every case, the improvement in production, cost and quality has been almost phenomenal.

Pickling speeds of 100 ft. per min. or slightly over were once considered very good. I remember well a long discussion in connection with the first continuous strip pickler which we built because, due to certain characteristics of the motors, the speed of the strip could not be brought below about 42 ft. per min. This was only six years ago, and at the time the operators thought it was quite a serious thing that they could not move slower than 40 ft. per min. The only complaints I have had recently are that the pickler will not go over 260 ft. per min., and when I point out that if gears are changed to give a speed of 300 ft. per min., they cannot go slower than 85 or 90 ft. per min., they laugh and say, "Who wants to go as slow as 85 or 90 ft. per min.?"

In addition, the production has gone up even a greater percentage than the speed. I have watched picklers run where the material is not stopped or even slowed down in the pickling tanks for eight hours at a time. All of the joining and severing operations, due to changing of coils in the uncoiler and coiler, as well as cutting out bad edges, etc., as required by the inspection department, are taken care of while slack is accumulated in or withdrawn from the looping pits at the entry and exit ends of the line of tanks. The increase in pickling production can be attributed to:

1. Better scale produced in the hot strip mill
2. Better knowledge and use of acid concentration and agitation in the pickle tanks
3. Installation and proper use of processing uncoiler at the entry end of the line
4. Proper arrangement of machinery to allow the continuous passage of the strip through the pickling tanks
5. Design of the machinery so that a minimum of time is lost due to breakdowns

In the tin plate department, leaving the mills out of the discussion, probably the most phenomenal increase has been in shearing. I remember that on the first automatic strip tin plate shearing unit on which I had any experience, if we exceeded 45 ft. per min., we might get variations of $\frac{1}{4}$ to $\frac{3}{4}$ in. in length between individual sheets. If we cut from 40 to 45 ft. per min., we could expect to shear within $\frac{1}{16}$ in. plus or minus, or a total variation of $\frac{1}{8}$ in., which was considered pretty good. When we sheared 10 tons in 8 hours, we considered that we had done a good day's work, and when we sheared 11 tons it was phenomenal, and probably someone had run too fast and there was a lot of poor product.

Today we have to guarantee and actually maintain an accuracy of $\frac{1}{64}$ in. plus or minus, and average tonnages of 60 and 65 tons per 8 hours while maintaining this accuracy are easily accomplished. A tonnage of considerably over 100 tons in 8 hours has actually been obtained. Such tonnages have been available for several years, but such tonnages with the extreme accuracy

mentioned above are a rather new thing in the strip tin mill.

Even though the automatic equipment used for tinning cold reduced tin plate is almost identical to that used for tinning hot rolled tin plate, many small improvements in machinery, combined with the activity and ingenuity of strip mill operating men, have resulted in the production of cold reduced tin plate exceeding anything I have heard of on hot rolled tin plate.

It must be remembered that as little as two or three years ago, every tin house man was sure that strip was very much harder to tin than hot rolled material and that the production obtained on hot rolled could never be reached on strip.

Also, tin houses have been operated 21 turns per week with entire satisfaction, which would have horrified any tin house man only three or four years ago.

The two new developments in tin mill strip; that is, continuous temper tower annealing and the continuous tinning unit, while accounting for little tonnage at present, bid fair to accomplish changes in the industry as extraordinary as those discussed in connection with pickling and shearing.

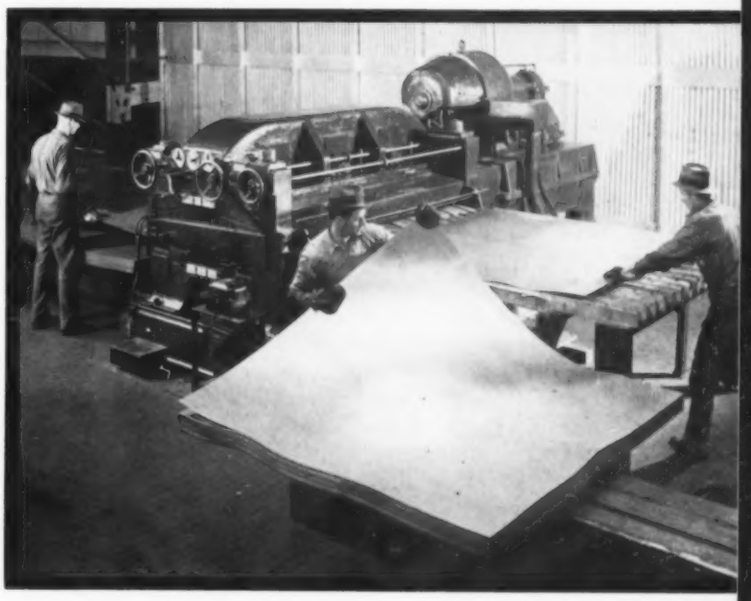
The strip mill has also brought many advances in box annealing. By far the largest proportion of strip mill tonnage is now box annealed in cover type furnaces where the furnace is brought to the material and placed over it, and the heat is applied by radiation from tubes rather than by direct flame. Practically all strip is annealed in a protective atmosphere to prevent the formation of scale. The quality of box anneal is very much higher than that considered possible before the development of the strip mill.

In the cold reduced sheet department, improvements have been very much parallel to those of the tin mill department in that the shearing and annealing and, of course, the continuous pickling have shown the same improvements.

Improvements in galvanizing are quite pronounced. Slight mention has previously been made of the grit-blasting of certain material for culvert stock, which has produced great savings in cost and a much better product. Culvert stock, usually having a very heavy coating, is the opposite extreme from the most recent improvement. This consists in the more economical and higher quality production of tight coat material which has a very light and very adherent galvanized coating. Several of these new units are now in operation and, while most of the production so far has been on hot rolled material, tests have been made on cold reduced material, both in sheet and coil form, that indicate that a very high quality product at a low cost can be obtained.

Improvements in the hot strip finishing department have probably not been as pronounced as those in the cold reduced department, mostly because there is such a very wide variety of operations to be performed and it is nearly impossible to make a continuous process for performing them. The greatest exception is the barrel stock line, which has been discussed previously. This was made possible by the processing uncoiler, which eliminated the necessity of annealing and temper passing hot rolled strip for a satisfactory barrel stock. This is also probably the very shortest treatment of anything shipped from a strip mill, since the hot rolled

The processing uncoiler is used in various finishing units, particularly for the first uncoiling of the hot rolled coil.



The backed-up roller leveler, which has been widely applied, is the result of wide material and the demand for increased flatness.

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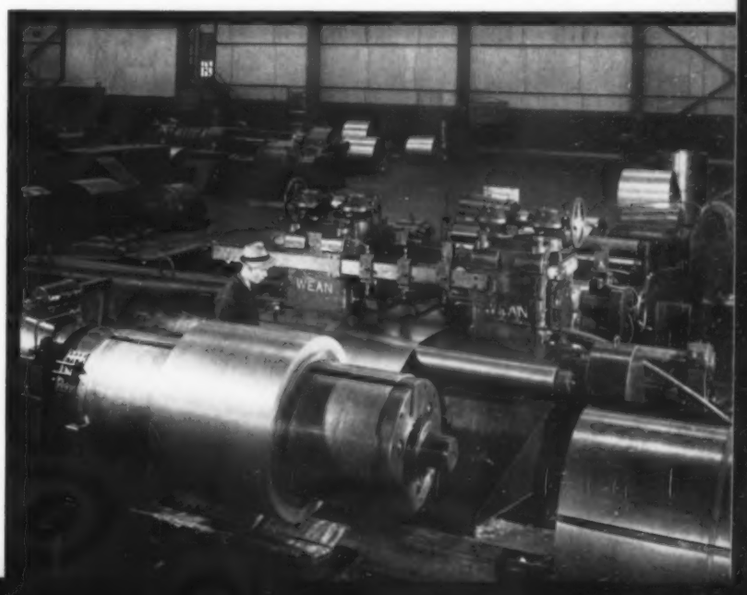
View of 77 in. recoiling line, with coil holder, side trimmer and expanding head type reel.



strip is simply passed through one line and is then ready for shipment.

The uncoiler has also eliminated extra operations on hot strip material other than barrel stock, as well as on cold reduced material. This is due to the fact that coil breaks are eliminated when the strip is uncoiled through this machine, and expensive processes for rendering them less harmful are eliminated. It is interesting to remember that once strip has been uncoiled through this machine, coil breaks will not occur in subsequent operations before annealing, no matter how the material is coiled or uncoiled.

A rule becoming more and more universally accepted is that the first time hot rolled strip is uncoiled for any purpose, it should be in a processing uncoiler.

One machine used a great deal in this department as well as in both of the cold reduced departments should be mentioned at this time, since it has undergone a very great improvement in the past few years. That is the backed-up roller leveler. With the demand for increased flatness and increased width, it soon became apparent that the conventional 2-high roller leveler would never give satisfactory results on a great portion of the material. As the material became wider, the rolls necessarily became longer and then, to prevent springing, they became larger. Larger rolls obviously cannot level material as well as small rolls. The backed-up leveler, whereby the small long rolls are supported above and below the pass line by as many as three sets of backing rolls has solved this problem very satisfactorily.

A great deal of improvement in strip finishing equipment is due to the close cooperation of electrical manufacturers and machinery builders. It is now quite common practice for many steel companies to purchase a complete line of equipment from a machinery builder, including motors and controls, thus allowing the very closest cooperation between the people supplying all the equipment on the line. I believe that, due to this cooperation, the engineers of electrical companies have suggested many changes in machinery which have been of great assistance to machinery builders, and that the mechanical engineers designing machinery have similarly suggested many changes to electrical equipment which have benefited the electrical companies.

One particularly noticeable trend is the use of variable voltage control on many lines, and it is very interesting to note that often wide speed range and smooth control of speed can be obtained by this type of control at no more expense than by conventional field control. This is due to the fact that the saving in motors will often be as great as the cost of the necessary motor generator set. Ward-Leonard control not only makes a smoothly operating line at varying speed but is often a great help to the steel mill electrical department when their existing motor generator sets are loaded to capacity and some new equipment is being installed.

Another great help in many finishing processes has been the rapid development of temperature control equipment, especially the adoption of proportioning fuel control in all heating operations. At practically every point where heat is used, particularly in annealing and coating operations, the most modern type of temperature control equipment has been found well worth its additional cost.

Although I have discussed with some enthusiasm the improvements that have been made in strip mill finishing equipment, we must not lose sight of the fact that great improvement must be made in the future in order to lower costs, thereby obtaining greater outlets for production and improving quality to meet the customers' ever-increasing demands. I think that strip mill finishing department superintendents will agree that customers can never be kept satisfied for any great period of time. As soon as a way is found to satisfy one set of demands, they think up new ones or greatly reduce the tolerances on their previous ones.

So far, strip mill equipment builders and supervisors have been able to meet practically every demand that has been made, but we realize that in this field of steel manufacturing there is not likely to be any let-up in striving for improved quality and production for many years to come. All of us are aware of certain places where the operation is far from ideal at present. We are sure that satisfactory methods and equipment will be developed to eliminate these spots in the future, as well as to considerably increase the efficiency of all operations which we now consider as being very good.

DISCUSSION

PRESENTED BY

G. G. BEARD, *Manager,* Proposal Department, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

C. L. McGRANAHAN, *Assistant General Superintendent,* Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

L. F. COFFIN, *Superintendent,* Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

D. A. McARTHUR, *Chief Engineer,* Wean Engineering Company, Warren, Ohio.

G. G. BEARD: I would like to ask Mr. McArthur if he could give us some idea of the capacity of the temper tower continuous strip annealing furnace referred to in his paper.

C. L. McGRANAHAN: I would like to compliment the equipment manufacturers on the progress that they have made during the last ten years on the turning out of new, advanced and novel ideas of strip mill finishing equipment. However, I would like to issue a little challenge to them today. Turn out something that can handle small orders in an economical way. The usual equipment which we see is very satisfactory for large orders, but you must turn out equipment which will handle 10,000 or 15,000 pound orders in place of a 10,000 ton order. To the best of my knowledge there are no satisfactory small units today which will handle a 10,000 pound order in a very economical manner except on individual units operated by hand.

I personally think the electrical manufacturer today is ahead of the machinery equipment builder.

I am not satisfied with the tonnage we are getting on shear blades. It does not seem to me that there has

been much progress made in the development of new shear blades since the advent of the high-carbon, high-chrome blade about 1926 or 1927.

I believe that there is still considerable progress to be made in the strengthening of certain parts of the shearing equipment, especially with regard to the shearing of scrap. I do not know of any satisfactory scrap shear on the market today which will handle the range listed by the manufacturer as the capacity of the slitter which is in the line. Listening to the sales representatives, it would seem that they never experience any difficulty, but we know that when we get the equipment in the mill it will not work on the heavier gauges.

The finishing department operators will tell you that it isn't uncommon to have fifty per cent of their orders amounting to ten tons or less, and that with most of the shear lines today it may take an hour to set it up for the particular size and then ten minutes to run the order. It seems to be the impression of some of our customers who place orders with our sales department that there is no limit to what can be accomplished in a modern strip mill without any additional expense or inconvenience other than pushing a button which starts up a shearing line and automatically turns out a perfectly flat sheet with two prime sides and they consider this operation feasible when working with mills operating between 1000 and 1500 tons every eight hours. I have yet to see equipment which will do this continuously twenty-four hours a day for days at a time.

The finishing lines as manufactured today are excellent lines for large orders but we are continually receiving orders which we would hesitate to place upon one of the commercial lines due to the customer's requirements for freedom of surface defects or accuracy of shearing. This is not intended as a reflection on the ability of the equipment manufacturers to turn out an accurate machine, but is due to hazards of operation which are encountered on all the present equipment and is a feature that should be given due consideration.

It would be interesting to have someone work up figures of economies which could be realized in the studies mentioned by Mr. McArthur if the layouts were made so that all orders could be put through in a regular routing. It would be an ideal situation if you could get the customer to take the orders from the finishing floor as soon as the processing has been completed. We know that our finishing departments are becoming warehouses for the customers. It is not uncommon to finish a large order and have it suspended just as you shear the last sheet.

The improvement that has been made in finishing equipment during the last ten years has been quite remarkable and very satisfactory tonnages are being produced on large orders and reasonable accuracy from a shearing standpoint is being secured. However, I am eagerly awaiting the day when we can secure equally satisfactory equipment for handling a five-ton order.

L. F. COFFIN: The increasing speeds of pickling lines up to a continuous running rate of 350 ft. per min. is frequently accompanied by an increased temperature of the pickling bath up to 210 to 215 degrees and at times 220 degrees F. This has created a mechanical problem that is serious. What happens in the continuous pickler tank, rubber lined and brick lined with the brick laid in the usual sulphur base cement is that an increase in temperature of the brick will tend to bend the angles or break the bolts at the joint at the center of the tank. In addition, at a temperature of 205 degrees F., the sulphur base cement changes its crystal form and expands about one-half of one per cent. This creates a tremendous pressure on the joint and results in the breaking down of the joints adjacent to the bath. This expansion plus the expansion due to increased temperatures of the brick will, besides straining the angle joint, also cause failure of the rubber spliced band at this same joint.

At one plant having two continuous pickling lines feeding two 5-stand tandem cold reduction mills for tin plate, there has just been completed an overhauling of these pickling lines without interrupting operations. A 5 ft. section of brick work in the center of each tank was cut out and two $\frac{3}{8}$ in. rubber expansion joints inserted in the new brick work. At the same time the rubber strip covering the joint between the two halves of the tank was renewed and about $\frac{1}{2}$ in. in depth of all the sulphur base cement joints in the brick work was scraped out and repointed with a phenolic resin cement. It is believed that this will be a fairly permanent repair.

It is suggested to those operating these continuous pickling tanks at such elevated temperatures, that an examination be made of any tendency to bend the angles at the center of their tanks as this will be a forerunner of future trouble.

Regarding the question of accuracy in speed of cutting tin plate on shear lines after skin passing, it should be borne in mind that when these lines run at such speeds and accuracies, they cause a difficult mechanical maintenance problem involving a skilled force able to analyze and correct causes of the variations in lengths so cut. The solution of these problems has made necessary the purchase of accurate gear cutting machinery and accurate grinding equipment. Without such equipment, the proper maintenance of these shears is almost impossible.

D. A. MCARTHUR: The only exact question is Mr. Beard's about the tonnage of temper tower machine units, and we expect about six to eight tons per hour, although this may be exceeded and it may change when more of them get in operation and it is found out exactly what they can do.

I had meant to point out previously a couple of obvious advantages of these units, particularly that you can have identically the same temper throughout the length of the coil, you can more accurately control your temper, and you can finish a coil in about half an hour after it starts instead of twenty-four to forty-eight hours.

Referring to Mr. McGranahan's comments, he has brought up a few bad points in finishing equipment, and, if we could find something to give the small order people, we would certainly have something. We are well aware of that. Referring to the discussion of the pickle tanks, we are aware that temperatures have gone up very considerably in the past few years and any new tanks will be put in with more expansion joints and with different material. It has been surprising to me how relatively little trouble we have had with the tanks that were put in five and six years ago when people have gone to the temperatures they have. There has been some trouble but it hasn't been as great as one might expect.

ELECTRICAL EQUIPMENT

for Armco Slabbing Mill

By A. F. KENYON, *Steel Mill Engineer*

WESTINGHOUSE ELECTRIC AND

MANUFACTURING CO., EAST PITTSBURGH, PA.

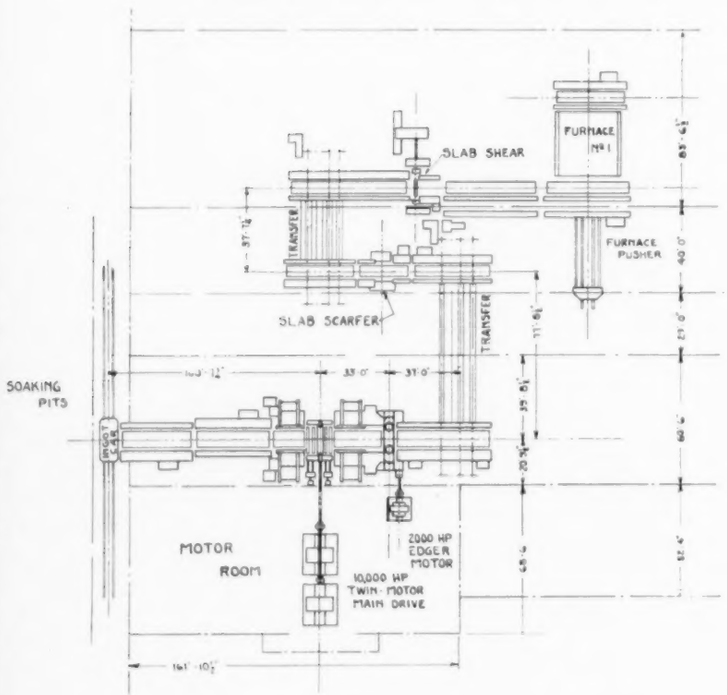
PRESENTED BEFORE A. I. S. E., SPRING CONFERENCE, CINCINNATI, OHIO, APRIL 1 AND 2, 1940

▲ THE arrangement of the reversing slabbing mill, and of the 80 in. wide continuous hot strip mill, at the Middletown plant of the American Rolling Mill Company, is different from the arrangement in most other plants producing wide strip, in that the slabbing mill is designed to produce slabs up to the maximum width of strip which can be rolled in the strip mill, thus eliminating the broadside spreading stand and slab squeezer from the strip mill layout, and enabling the rolling of full weight coils over the entire range of strip widths.

In most plants, limitations in ingot size and slabbing mill arrangement usually limit the maximum width of slab to 60 in. or less. Then for strip of less than the maximum slab width the slab is rolled straight-away through the strip mill, and the length and weight of finished hot strip are limited only by the size of slab which can be rolled and handled through the reheating furnaces. However to produce strip wider than the available slab, the slab must be turned and rolled broadside through a spreading stand to spread the slab to the desired strip width. The largest spreading stand thus far installed in a strip mill line is 130 in. wide, and other strip mills have spreading stands ranging from 96 to 120 in. wide. Thus on these mills the length of hot strip, wider than the available slabs, is limited by the length of slab which can be cross-rolled in the spreading stand, and this length may be only half that which otherwise could be used.

In the Middletown installation, the slabbing mill is arranged so that the ingot may be cross-rolled and spread to any desired width, after which it is turned and rolled lengthwise to the finished slab. Thus all widths of strip may be rolled straight-away from full length slabs, without any cross-rolling in the strip mill, and wide strip may be rolled in the same long lengths as the narrower strip. The largest ingots now being rolled are 20 in. x 57 in., weighing about 17,500 lb., from which are finished 4 in. x 74 in. x 16 ft. 0 in. long slabs. However the mill is capable of handling much heavier ingots, and when changes at the open hearth and soaking pits are completed, it is expected to roll ingots 20 in. x 63 in.—25,000 lb. maximum weight, which will enable the production of 5 in. x 74 in. x 18 ft. 0 in. long slabs, and strip coils of 300 lb. per in. of width.

FIGURE 1—General layout of slabbing mill, showing relative location of pits, horizontal and vertical roll stands, etc.



MILL ARRANGEMENT

The general arrangement of the slabbing mill is shown in Figure 1, which indicates the relative locations of the soaking pits, horizontal and vertical roll stands, main drive motors, tables, transfers, scarfing machine, shear, etc. The mill is of the modified universal type,

consisting of a main horizontal roll stand, and an auxiliary vertical roll edging stand. The edging stand is located 33 ft. from the main stand, to provide room for turning the ingot and so that the slab will not be in both stands at the same time.

The main horizontal mill rolls are nominally 45 in. diameter by 120 in. long body, with 27 in. diameter by 33½ in. long necks. The maximum opening between the upper and lower rolls is about 36 in. The mill spindles are 28 ft. 0 in. long from center to center of the universal couplings. The lower roll is located about 19½ in. above the lower roll drive motor, so that the lower spindle operates at a fixed angle of about 3.3 degrees. During the rolling of a 20 in. thick ingot to 4 in. thick slab, the position of the upper roll varies from 10½ in. to 25½ in. below the upper roll drive motor, so that the upper spindle operates at an angle varying from 1.8 to 4.3 degrees. The distance from center to center of the upper and lower drive motors is 94 in. The horizontal mill operating speed range is 40/80 rpm., corresponding to about 475/950 ft. per min., although in normal operation the speed usually does not exceed 50 rpm., or 600 ft. per min.

The vertical roll edging stand is the largest vertical roll mill ever built, with rolls nominally 40 in. diameter by 24 in. long. The roll opening is from 20 in. minimum to 76 in. maximum. The rolls are connected to the fixed spur and miter gear drives by means of 9 ft. 6 in. long vertical universal spindles, which operate at angles up to about 7 degrees maximum on either side of the vertical position. The use of fixed spur and miter gear drives, assembled in rigid cases and running in oil, with universal spindle connections to the vertical rolls, assures a much stronger and more efficient drive than was possible where the miter gears were mounted direct-was possible where the miter gears were mounted directly on the rolls, and enables the use of larger diameter edging rolls and the transmission of greater torque to make heavier edging drafts. The gear reduction between the 2000 hp., 100/200 rpm. motor and the vertical edging rolls is 3.45:1, giving a vertical roll speed of 29/58 rpm., or about 300/600 ft. per min.

Figure 2 is a general view of the slabbing mill, showing the main horizontal roll stand in the foreground, and the vertical roll edging stand in the background.

FIGURE 2—View of slabbing mill, showing horizontal roll stand in foreground, vertical edging stand in background.

ELECTRICAL DRIVE

The arrangement of the electrical equipment in the motor room is shown by Figures 3 and 4. Figure 3 is a general view of the motor room, showing the horizontal mill main drive motors in the foreground extending across the center of the motor room, and the exciter sets, flywheel motor generator set, and switching and control equipment, in the background. In the immediate foreground is shown a part of the variable voltage motor generator set supplying power for the main mill tables and slab shear. Figure 4 is a plan drawing showing the locations of the principal electrical equipment, and the relation of the electrical drive equipment to the main and edging mill stands.

The upper and lower horizontal rolls of the main mill stand are separately driven by two 5000 hp., 700 volt, 40/80 rpm., single armature, direct current, reversing motors, constituting a 10,000 hp. twin-motor drive, of 1,300,000 lb.-ft. rated full load torque, and 3,600,000 lb.-ft. maximum peak torque capacity. The lower roll drive motor is installed close to the mill, and the lower spindle is connected directly to the motor shaft. The upper roll drive motor is installed farther away from the mill, and drives through a jackshaft over the top of the lower motor. The jackshaft is connected to the motor shaft by means of a rigid flange coupling, and the outer end connecting to the upper spindle, is carried in a third pedestal bearing which is supported on an A-frame from the lower motor bedplate. A heavy duty thrust bearing is provided on the coupling end pedestal of each of the motors, to absorb any unusual emergency thrust from the mill. Light duty thrust bearings are also provided on the commutator end pedestals to limit the movement toward the mill, as experience with earlier twin-motor drives had shown that the universal joints of the mill spindles may induce endwise oscillation of the motor armatures.

The 5000 hp. motors are designed with small diameter long core armatures, to reduce the center to center distance between the upper and lower motor shafts, and also to reduce the armature inertia, and thereby permit more rapid acceleration and deceleration. The center to center distance between the upper and lower motor shafts is 94 in. The armature inertia is approximately 1,600,000 lb.-ft. squared per motor, or 3,200,000 total for the 10,000 hp. drive. The center to center distance and armature inertia could be made still lower by resorting to double armature construction of each of the 5000 hp. motors (as was done on two equipments of the same rating built in 1930), however this further gain would be relatively small, and obtained only at the expense of greatly increased cost, much longer floor space, and considerably reduced efficiency. The present design

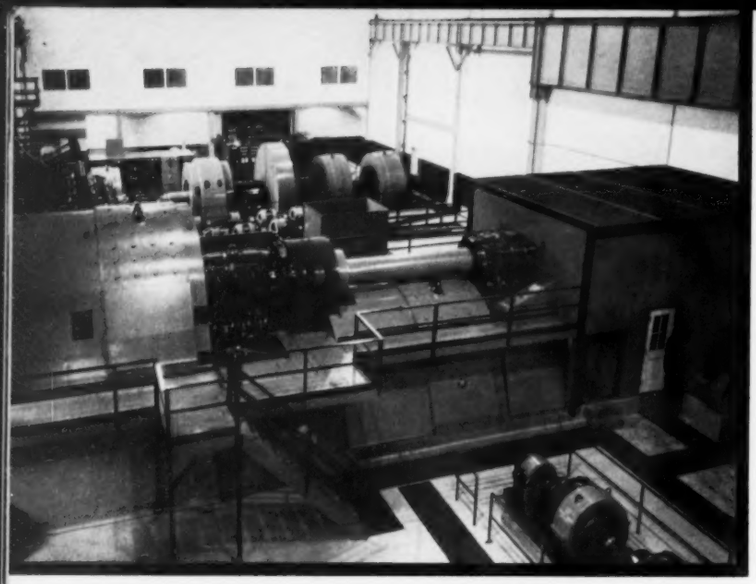


FIGURE 3—General view of motor room showing main drive motors, together with auxiliary equipment and switchgear.

therefore represents a compromise, giving due weight to the various conflicting factors.

The vertical rolls of the auxiliary edging stand are driven by a 2000 hp., 700 volt, 100/200 rpm. single armature, direct current, reversing motor, flexibly coupled to the miter gear cross shaft. This motor is also designed with small diameter long core armature to reduce the inertia and thereby minimize the torque for acceleration and deceleration. The edger motor armature WR^2 is approximately 150,000 lb.-ft. squared.

Figure 5 is a photograph showing the 10,000 hp. twin-motor drive for the horizontal rolls in the foreground, and the 2000 hp. edger motor in the left background. This photograph also indicates the location of the operator's pulpit in the wall overlooking the table between the main and edging mills. With the wide separation between the main and edging mills, this pulpit location is most advantageous in providing maximum visibility of all parts of the mill.

The variable voltage direct current power for the operation of the two 5000 hp. main horizontal roll motors and the 2000 hp. edging mill motor, is supplied by a 9000 kw. flywheel motor generator set, which consists of three 3000 kw., 700 volt, direct current generators, a 7000 hp., 6600 volt, 3 phase, 60 cycles, 355 rpm., wound rotor induction motor, and a 15 ft. 0 in. diameter, 190,000 lb., steel plate flywheel. At 360 rpm. synchronous speed, the stored energy of all of the rotating parts of the set is approximately 235,000 hp. seconds. Approximately two minutes time is required to start from rest and bring the set up to full speed. With dynamic braking of the induction motor, the set may be brought to rest in about three minutes.

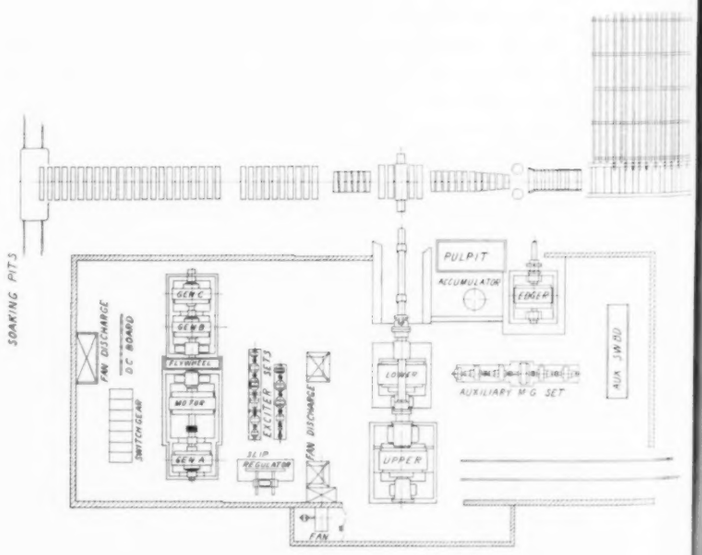
Normally the 12,000 hp. total capacity of the three reversing motors would call for the installation of a 10,500 kw. set, however in the Middletown installation the 10,000 hp. main mill drive and 2000 hp. edging mill motor are not loaded simultaneously, so that the 9000 kw. set is of ample capacity.

The schematic connections for the slabbing mill main drive equipment are shown in Figure 6. The three 3000 kw. generators are connected in parallel and feed to a common bus, and the two 5000 hp. main horizontal roll motors and the 2000 hp. edger motor are fed from this common bus. High capacity air circuit breakers are provided in the positive line lead from each of the three generators, and in the negative line lead to each of the three motors. The circuit breakers are pedestal mounted, and are installed in the basement on low concrete piers.

A differential series field winding and cross cumulative series field winding on each of the 3000 kw. generators assure stable parallel operation and equal division of the total load.

A similar although somewhat more complex scheme is used for the parallel operation of the two 5000 hp. motors driving the upper and lower rolls of the main mill stand. The steel ingot or slab provides an effective mechanical connection between the upper and lower rolls, and the electrical interconnections between the upper and lower roll drive motors are laid out to balance the loads rather than to rigidly match the speeds of the two motors. Two pilot series exciters and two load balancing series exciters provide this load balancing effect. The pilot series exciters are excited from the drop across the interpole and compensating windings of the upper and lower roll motors, respectively, and their output voltages are hence proportional to the loads on the two motors. The upper motor pilot series exciter excites the cumulative winding of the upper motor load balancing series exciter, and also excites the differential winding of the lower motor load balancing series exciter. Similarly the lower motor pilot series exciter excites the cumulative winding of the lower motor load balancing series exciter, and the differential winding of the upper motor load balancing series exciter. In turn the load

FIGURE 4—Layout showing locations of principal electrical equipment, with its relation to the mill stands.



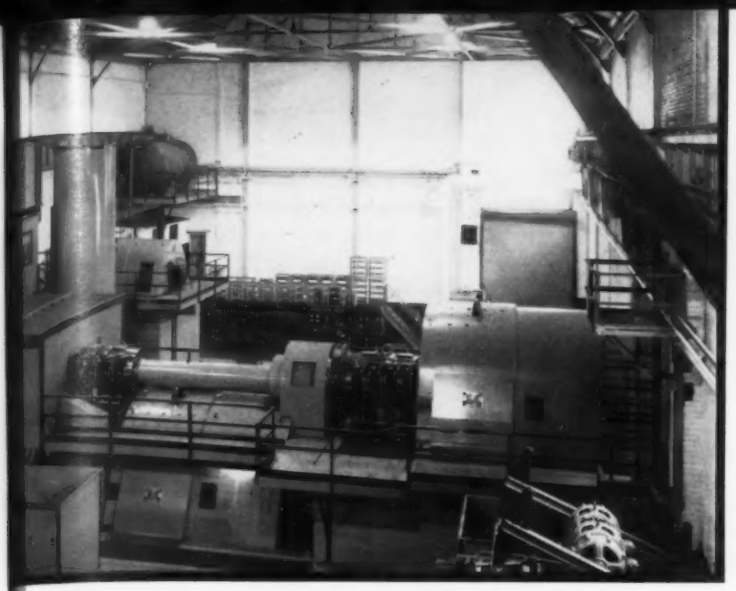


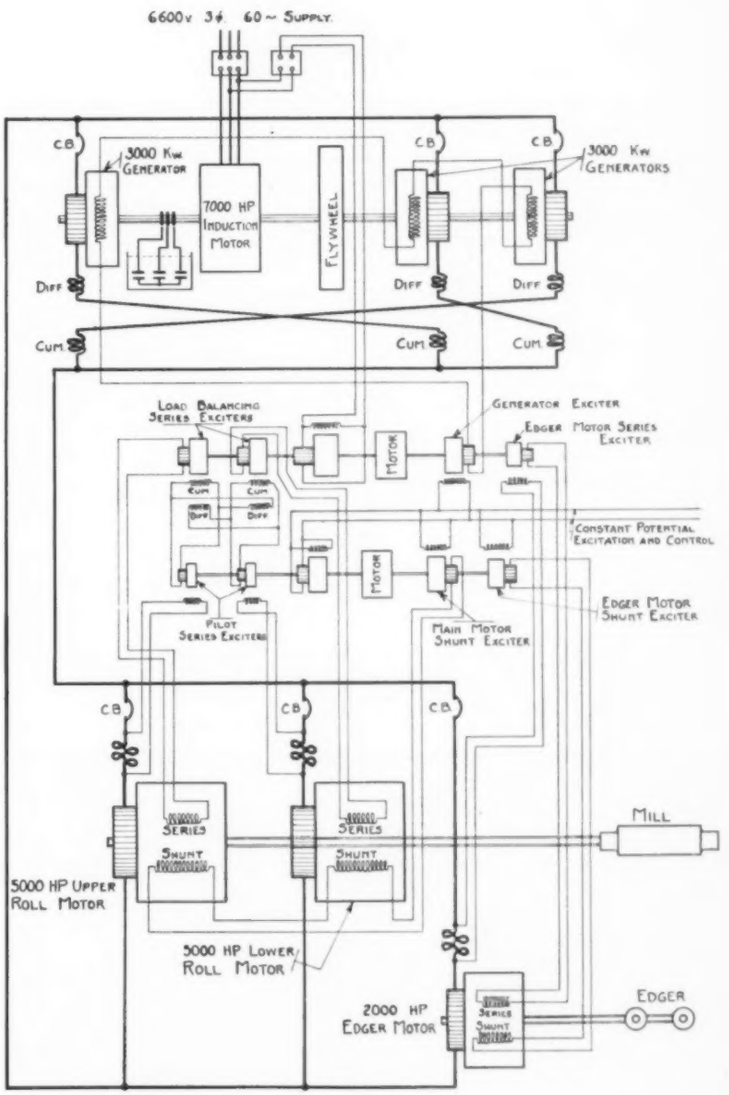
FIGURE 5—The 2000 hp. edging mill motor is here shown in the left background, over the top of the main drive motors.

balancing series exciters furnish the excitation for the auxiliary series field windings on the two 5000 hp. motors. The load balancing series exciter cumulative windings have more ampere-turns than the differential windings, so that the exciter output is of such polarity that the 5000 hp. motor series excitation is cumulative with respect to the shunt excitation, thus securing slightly drooping or compound speed-load characteristic. Assuming balanced load conditions on the two motors, it is obvious that the excitation of the two motors will likewise be balanced. However assume that the upper motor tends to take more than its share of the total load. This will tend to increase the cumulative excitation and reduce the differential excitation of the upper motor load balancing series exciter, and thereby increase the net series excitation of the upper motor, also will tend to reduce the cumulative excitation and increase the differential excitation of the lower motor load balancing series exciter, and thereby reduce the net series excitation of the lower motor. Hence any tendency of one motor to take more than its share of the load results in increasing its own net series excitation and reducing the net series excitation of the other motor, thus restoring the equilibrium and maintaining the desired load balance. In practice it is found desirable to make the lower motor carry slightly higher load than the upper motor in order to secure a slightly upward delivery of the slab and avoid bumping the table rolls. The desired unbalance is readily secured by adjustment of the field circuit resistors.

The main excitation for the generators, main horizontal roll drive motors, and edger motor, is furnished by individual exciters, and variation in the excitation of the main machines is effected by working in the exciter field circuits, thus requiring the control equipment to handle only the small exciter field currents, and enabling the use of relatively small contactors and relays. Figure 7 shows the two exciter motor generator sets with the ten exciter units required for the various excitation circuits, and Figure 8 shows the metering and variable voltage field control panels for the complete main drive equipment.

The electrical equipment in the slabbing mill motor room is ventilated by a down-draft cooling and recirculating ventilation system. Figure 9 is a longitudinal section through the basement and lower part of the motor room, and indicates schematically the arrangement of the ventilating equipment for the main machines. Each of the three reversing mill motors and the generators and induction motor comprising the flywheel motor generator set is equipped with a single sheet steel rear endbell with large opening around the shaft so that the cool air from the motor room is drawn into the machines. The slow speed reversing motors are equipped with complete enclosures over the commutator end, the high speed generators are equipped with partial enclosures over the commutators, and the induction motor is

FIGURE 6—Diagram showing the schematic connections for the slabbing mill main drive equipment.



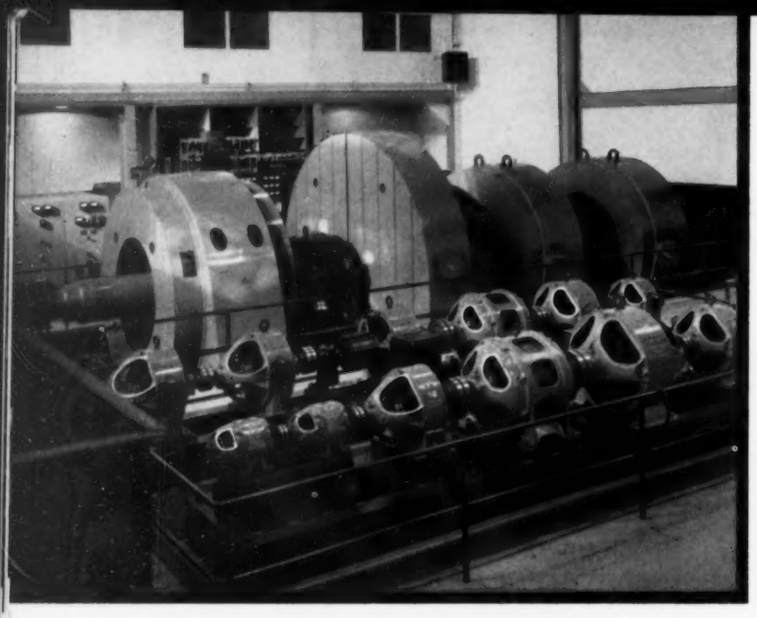


FIGURE 7—Mill drives operate from the motor generator set in the background, with excitation from the sets in foreground.

made with bottom discharge chimney frame, so that the warm air from the machines is directed down through the machine pits to the finned tube surface air coolers, which are set before openings in the foundation walls. The recirculating fans then return the cooled air upward through vertical stacks to the motor room. A make-up filter and fan (not shown in Figure 9 but shown on the plan arrangement Figure 4), keeps the motor room under pressure to prevent infiltration of dirt, also supplies the air which is bled from the recirculating system for the ventilation of the operator's pulpit and for the forced ventilation of some of the mill auxiliary motors.

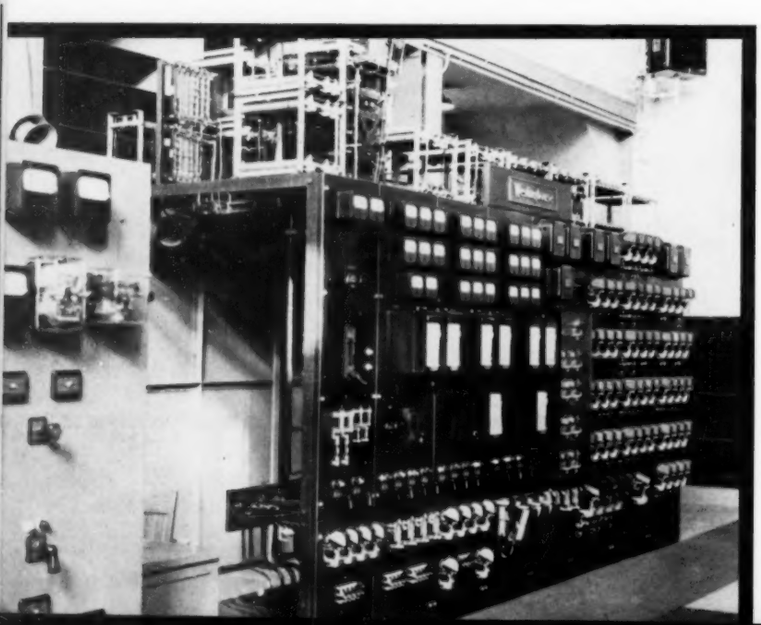
The air cooler handling the air from the two 5000 hp. and one 2000 hp. motors, is made up of four sections, having a total heat transfer surface of 8400 sq. ft., and the cooler for the 9000 kw. motor generator set also consists of four sections, totalling 9360 sq. ft. The coolers are designed to cool the air to 80 degrees F. when using 60 degree F. cooling water, and under maximum load conditions will absorb 2000 kw. of heat loss from 225,000 cu. ft. per min. recirculated air, requiring about 1200 gal. per min. cooling water.

The ventilating air for the three reversing motors is recirculated by two fans, each of a capacity of 60,000 cu. ft. per min. at 5½ in. pressure and each driven by a 75 hp. motor. The motor generator set air recirculating fan is of 100,000 cu. ft. per min. capacity at 4½ in. pressure, and is driven by a 100 hp. motor. The air makeup fan is of 37,500 cu. ft. per min. capacity at 2 in. pressure, and is driven by a 20 hp. motor.

There is provided a pressure circulating lubrication system to supplement the oil ring lubrication of the babbitt lined sleeve bearings of the 10,000 hp. twin-motor, 2000 hp. edger motor, and 9000 kw. flywheel motor generator set. The circulating lubrication system is of 40 gal. per min. continuous capacity, and consists of two separate receiving tanks each of about 1800 gal. capacity, rotary self cleaning oil filter, 100 gal. hydropneumatic pressure tank, two motor driven oil circulating pumps, water cooled heat exchanger to cool the oil to about 100 degrees F. before distributing it to the bearings, and the necessary gauges, sight feed valves, and piping. The two large flywheel bearings on the motor generator set are quite heavily loaded and operate at quite high journal speed, so that they require artificial cooling in order to operate at reasonable temperature. This artificial cooling is effectively obtained by flooding each of these bearings with about 12 gal. per min. of cool lubricating oil. The other smaller motor generator set bearings and the reversing motor bearings do not require such artificial cooling and the connection in the circulating lubrication system is desirable only to assure the continuous filtration and removal of impurities from the oil, and to insure lubrication in case of sticking of an oil ring or other mishap.

A novel feature of this lubrication system is the provision of two separate oil receiving tanks, each of full capacity, so that the oil in one tank may be periodically "rested" and the impurities settled out, while the oil in the other tank is being recirculated and used.

FIGURE 8—View showing metering and variable voltage field control panels for the complete main drive equipment.



MILL AUXILIARIES

The arrangement of the Middletown mill necessitates operating characteristics of some of the mill auxiliaries quite different from the requirements of other reversing mills, and a brief description of some of the auxiliary drives may be of interest.

During the slabbing down of an ingot in the main horizontal mill, the total screwdown movement is only about 15 in. and the individual movements between passes are only an inch or so. The screwdown is therefore geared for the very moderate speed of about 80 in. per min., and is driven by two 100 hp. compound wound mill type motors, controlled by a duplex magnetic controller. The front and back screws are individually driven by the two motors, and the motors are tied together by a magnetic clutch, enabling separate operation of either screw to compensate for unequal bearing wear and thus control the uniformity of thickness of wide slabs.

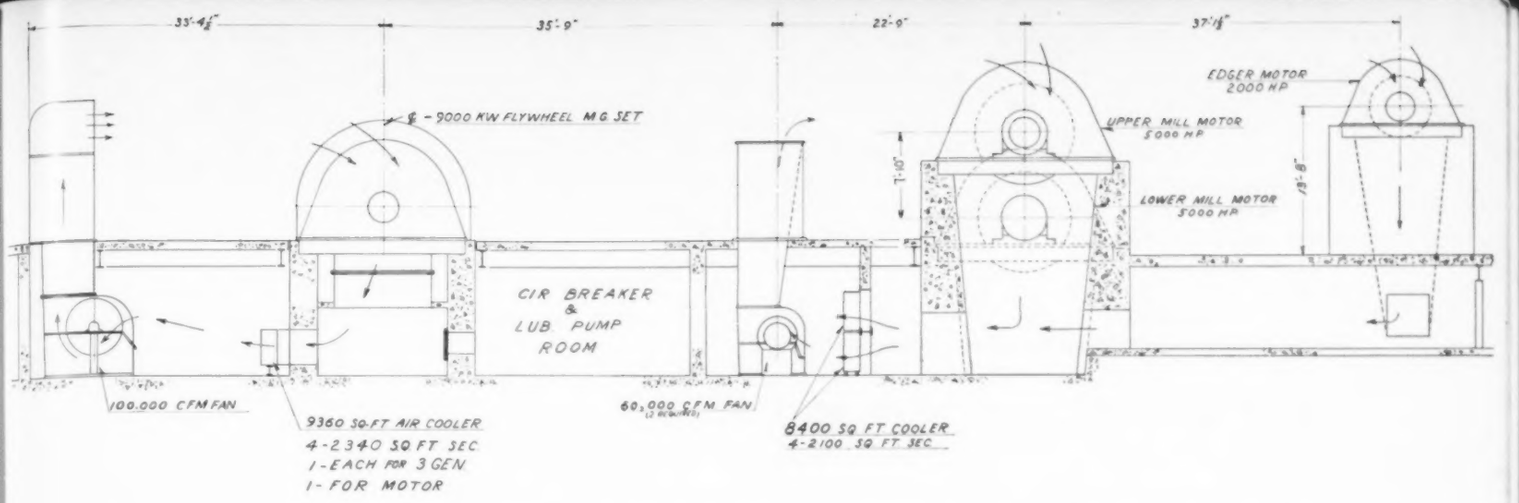


FIGURE 9—Longitudinal section through motor room basement showing arrangement of ventilating equipment for main machines.

The front and back main mill tables are unusual in that they provide for turning the ingot before and after the spreading passes as well as for passing the ingot back and forth through the mill. The tables are made up of tapered rolls, and alternate rolls are driven from separate lineshafts and motors. By rotating all of the rolls in the same direction the ingot is moved toward or away from the mill, however by rotating alternate tapered rolls in opposite directions the ingot is turned in a horizontal plane without longitudinal movement. The turning movement must be performed at lower speed than the normal forward and reverse movement, and variable voltage control provides the necessary flexibility and accuracy. The two 75 hp. table motors and 50 hp. feed roll motor on each of the main tables are supplied from 200 kw. generators. The mill approach tables, and edger delivery and runout tables are operated by the usual magnetic controllers.

The slab shear is capable of shearing a 6 in. thick by 76 in. wide hot slab, and is geared to make about 12 cuts per minute, requiring two 275 hp. mill motors for its drive. For these large motors magnetic control becomes unwieldly, and requires considerable maintenance, so that the greater first cost of variable voltage equipment is justified by the smoother and more flexible operation, and the lower electrical and mechanical maintenance. Two 250 kw. generators supply power for the shear motors.

Transfer connections are provided so that if any one of the four variable voltage generators is out of service, the two shear motors may be connected in series and operated from one generator, and the front and back table motors operated from the other two generators. Figure 10 shows the variable voltage table and shear control panels, and part of the variable voltage motor generator set.

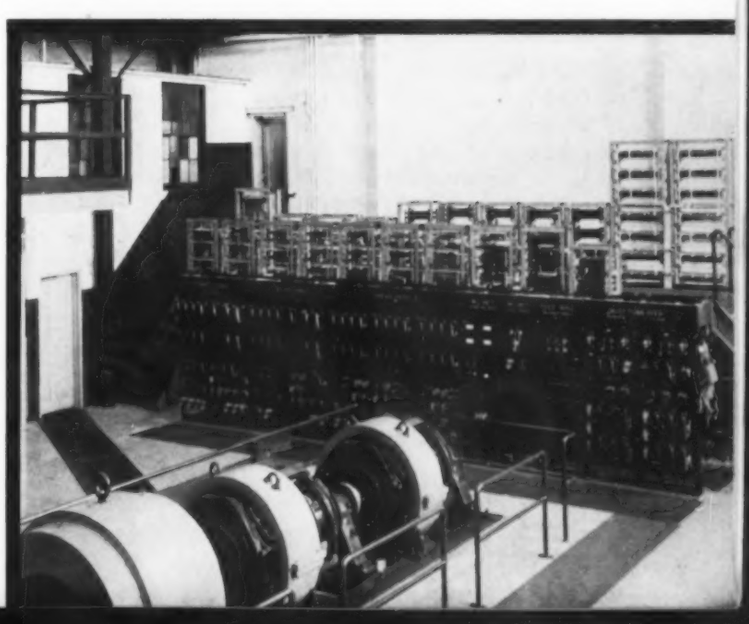
POWER DEMAND AND ENERGY CONSUMPTION

In the Middletown layout, hot slabs are delivered directly to the strip mill, and the slabbing mill rolling rate is gauged by the capacity of the strip mill rather than by limitations in the slabbing mill itself. Under these conditions the slabbing mill output has not reached record proportions, although entirely up to expectations.

Rolling 20 in. x 57 in.—17,500 lb. ingots to 60 in. wide slabs, the hourly output has exceeded 250 net tons of sheared slabs. In one month of good operations the mill produced 73,336 net tons of sheared slabs in 618.5 hours operating time, or an average of 119.2 net finished tons per hour.

During starting of the flywheel set the maximum peak load is about 6000 kw. During normal rolling the slip regulator limits the input to the flywheel set to about 4000 kw. The 15 minute demand of the slabbing mill substation, including the 900 kw. variable voltage auxiliary motor generator set and the 1000 kva. auxiliary transformer supplying the exciter sets, ventilating fans, oil pumps, etc., as well as the main drive flywheel set, averages about 2000 kw. and seldom exceeds 2500 kw. Over a four month period the input to the flywheel set averaged 8.32 kwh. per net ton of sheared slabs. The input to the 1000 kva. auxiliary transformer feeding the exciter sets, ventilating fans, oil pumps, heaters, etc., averaged 2.62, and to the 900 kw. variable voltage table and shear motor generator set 1.45 kwh. per net ton,

FIGURE 10—Variable voltage control for tables and shear are provided from this motor generator set and panel.



making a total of 12.39 kwh. per net ton of sheared slabs. It is to be noted that this total does not include the 250 volt auxiliary power for cranes and constant voltage mill auxiliaries, as these are supplied from a separate substation.

DISCUSSION

PRESENTED BY

W. A. PERRY, *Superintendent of Electrical and Power Departments,* Inland Steel Company, Indiana Harbor, Indiana.

L. A. UMANSKY, *Steel Mill Engineer,* General Electric Company, Schenectady, New York.

A. F. KENYON, *Steel Mill Engineer,* Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

L. V. BLACK, *Electrical Superintendent,* Bethlehem Steel Company, Bethlehem, Pennsylvania.

T. E. HUGHES, *Superintendent of Maintenance,* Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania.

W. A. PERRY: It is always interesting to note in the later installations of mills that the ventilating system is such that not only does the electrical system benefit by the cool air but so does the operator so in cases of this character you expect the man who stays in the motor room will give you more.

L. A. UMANSKY: Mr. Kenyon mentioned that each of the two mill tables is driven by two 75 hp. motors and one 50 hp. feed roll motor. Power is supplied to these three motors by a 200 kw. generator. One of the 75 hp. motors is, at times, reversed with respect to the other 75 hp. motor and the 50 hp. motor. Was a separate magnetic control provided for each motor, or the relative direction of rotation reversed by first stopping the table and by using generator voltage control only?

What type of generators have been employed for these tables and for the shear? Were they equipped with three fields (shovel type), as has been done on several recent installations of this type, such as at Inland, Edgar Thomson, and T.C.I.?

A. F. KENYON: The front and back main table and feed roll motors are controlled entirely by generator voltage. On each table drive one of the 75 hp. table motors is connected solidly to the 200 kw. generator and the other 75 hp. table motor is connected to the generator through a set of reversing contactors. Reversal of the relative direction of rotation of the two table motors, to accomplish the turning of the ingot on the table before and after the spreading passes, is effected by stopping the table and setting up for the reversed operation of the one motor by means of the reversing contactors. A single pole line contactor is also provided in the 50 hp. feed roll motor circuit, and this motor is disconnected from the generator while operating the table motors in opposite directions to turn the ingot on the table. Voltage relays are provided to prevent opening or closing the motor line contactors except at low generator voltage.

The 200 kw. generators supplying the table and feed roll motors, and the 250 kw. generators supplying the slab shear motors, are of the three field type, such as have been used for the variable voltage auxiliaries of several recently installed reversing blooming and slabbing mills.

L. V. BLACK: Since my experience with electrical equipment for reversing mills is limited to blooming mills rather than slabbing mills and since the general mechanical problems particularly from a mill arrangement standpoint are different from those problems encountered in the ordinary blooming mill layout, I hesitate in going into too much detail regarding this subject. However, Mr. Kenyon's presentation of a reversing slabbing mill has led me to believe that from a purely electrical standpoint there is much in common so far as the electrical drive equipment is concerned.

It is noted that the schematic connections for the operation of the three 3000 kw. generators shows them to be connected in parallel and feeding to a common bus with a differential series field winding and cross cumulative series field winding on each of the 3000 kw. generators. Is the net result of the interaction of these field windings such as to produce a drooping voltage characteristic with increase of load or do you actually get the effect of flat compounding?

The scheme used for the parallel operation of the two 5000 hp. motors driving the upper and lower rolls of the main mill stand by means of pilot and load balancing series exciters was most interesting. With this arrangement just how much droop in the speed load characteristic can be produced?

From the maintenance viewpoint, the question arises as to the accessibility and convenience of repairs. One of the most common diseases of all direct current equipment, as well as slip ring motors, is that of redressing of commutators and slip rings. Sooner or later we must be faced with that problem. Just recently at the Bethlehem Plant it became necessary to true up the commutators and rings of the fly wheel set used in connection with the 35 in. blooming mill. This problem was very easily accomplished by motorizing one of the fly wheel set generators. Power was supplied by isolating one of the motor-generator sets normally used to supply power to the mill auxiliaries and connecting its terminals to the terminals of the fly wheel set generator. Excellent control of speed was maintained with this arrangement for first turning the commutators or rings with a tool and then finishing with a polishing stone. The stone was held by the same tool head used for the turning operation.

Where a single motor is used for driving the mill rolls, some special device for turning the armature must be secured for commutator dressing. With the twin motor, one motor can be disconnected for machining of its commutator, while the other is used for the turning medium.

It has been noted that thrust bearings have been provided on the commutator end pedestals for the slab-

bing mill at Middletown to limit the movement toward the mill. It would be very interesting to know what experience you have had with twin motor drives inducing endwise oscillation of motor armatures, and what measures of correction have been applied.

A. F. KENYON: On the 3000 kw. main generators the differential series field winding and crossed cumulative series field winding each consist of one turn per pole, so that the two windings practically counterbalance each other with resultant slightly drooping voltage regulation practically the same as would be obtained from shunt wound machines. The control equipment includes a voltage regulator which varies the generator excitation to maintain practically flat voltage over the load and speed range.

The paper pointed out that the system of series excitation of the 5000 hp. upper and lower roll motors is arranged so that the net series excitation is cumulative with respect to the shunt excitation, thus giving the drooping speed load characteristic of a compound wound motor. The amount of droop can, of course, be varied by adjustment of the exciter and motor field excitations, however in usual practice the speed regulation from no-load to full load is made on the order of 7½ per cent.

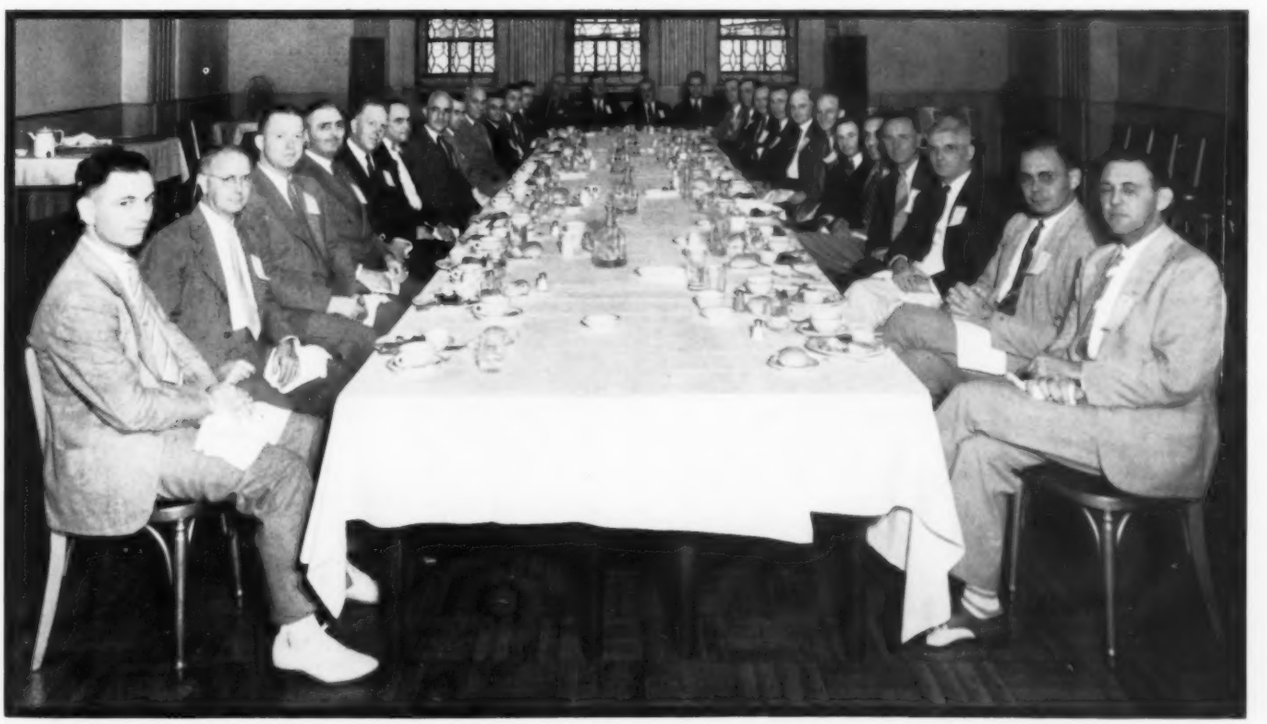
The action of the universal couplings on the mill spindles is no different with a twin motor drive than with a conventional pinion drive, but since it may affect the motor operation, the motor manufacturer must take precautions which would be the responsibility of the mill builder on a conventional pinion drive mill.

When the universal couplings operate at an angle, each revolution produces alternate pushing and pulling forces tending to move the motor armature and shaft endwise. This axial movement actually results when the friction sliding forces in the couplings are greater than the magnetic centering force of the motor. Under certain combinations of adverse conditions of inaccurate alignment of the spindles, insufficient support of the spindles by the spindle carrier bearings, and high coupling friction due to insufficient lubrication, the endwise oscillation has been of such magnitude as to cause quite severe bumping of the thrust bearings, at both ends of the motors. However with proper maintenance and lubrication of the spindle couplings the oscillation is not great, and the thrust surfaces come together only occasionally.

T. E. HUGHES: I was particularly interested in the feature of dynamic braking as applied to the motor on the motor-generator set in this installation.

A. F. KENYON: With reference to Mr. Hughes' comments, dynamic braking is now quite generally used for quick stopping of large wound rotor induction motors such as are used to drive flywheel motor generator sets or for direct mill drives. In this case the stored energy in the flywheel and other rotating parts of the set is extremely large so that even with dynamic braking a considerable time is required to bring the set to rest. With the present adjustments from 2½ to 3 minutes are required to bring the set to standstill, although if felt desirable the dynamic braking excitation could be increased and the set stopped in considerably less time.

BIRMINGHAM DISTRICT SECTION COMMITTEES MEET



The Birmingham District Section of the A.I.S.E. recently held a meeting of the three standing committees to map out their program for the coming year. In attendance at this meeting were the following: H. C. Kaeff, Howard Cobb, T. L. Mason, Andrew J. Malone, M. J. Booth, S. C. Ebbert, J. J. Graegan, R. L. Hall, W. W. Garrett, R. F. Wright, E. A. Hawk, C. R. Tinsley, H. T. Watts, Chairman, Birmingham Section, A. L. Lemon, Secretary, Birmingham Section, P. J. Bowron, Vice-Chairman, Birmingham Section, R. E. Sturdy, Sorsby Jemison, W. J. Donahue, Birger Thele, Harvey King, G. E. Thrash, R. E. Bobbitt, J. Roubicek, W. H. Beatty, W. P. Begley, F. B. Carney, and W. H. Mandy.

Safety Fuel Engineering

Compiled by the Fuel Department of the Maryland Plant, Bethlehem Steel Company, Sparrows Point, Maryland

PRESENTED BEFORE A. I. S. E., PHILADELPHIA DISTRICT SECTION, NOVEMBER 4, 1939

▲ THE fuel department has incorporated in its safety meetings the presentation of specially prepared papers dealing with the hazards to be encountered, and the safe practices to be followed, in the use of gaseous and liquid fuels in the Maryland Plant of the Bethlehem Steel Company.

The purpose of these papers is twofold: (1) educational; (2) pioneering.

It is our feeling that all members of the fuel department, the maintenance men who rebuild and repair furnaces and furnace equipment and the men in the plant who operate the furnaces, should be given the opportunity to acquaint themselves with these papers and to discuss and be alert to the various hazards and safe practices pertaining to their particular work. This will be accomplished by combining the papers into a book, parts of which will be presented at the safety meetings of the various departments.

The papers have been reviewed and re-edited to eliminate any repetitions, so that they may be incorporated in a safety code book. As the need arises they will be reviewed and additional sections will be added from time to time as our safety program continues. In this way they will soon cover our entire experience on the subject.

It is our hope that after the papers have been presented to the Association of Iron and Steel Engineers, the fuel engineers throughout this Association will prepare similar papers dealing with their particular safety problems. In this way it may be possible to incorporate all phases of safety fuel engineering into one Association Code Book which will be of great and lasting service to the industry.

The papers written to date and incorporated in this report are as follows:

Part I—Methods of Purging Gas Lines, Holders, Tanks, etc.—by G. J. Campbell
Part II—Carbon Monoxide and Its Detection—by J. S. Morris
Part III—Operation of Gas Safety Regulators—by D. G. Hisley
Part IV—Safety and the Burning of Blast Furnace Gas—by C. E. Duffy
Part V—Safety Procedure in Gas Fired Furnaces—by J. F. Black
Part VI—Precautions in the Burning of Premixed Gases—by H. L. Halstead
Part VII—Safety Procedure in Heavy Oil Fired Furnaces—by E. C. Davis

All of the authors of these sections are members of the fuel and combustion department of the Maryland Plant of Bethlehem Steel Company.

PART I—METHODS OF PURGING GAS LINES, GAS HOLDERS, TANKS, ETC.

By G. J. CAMPBELL

The purpose of this section is to outline some of the common hazards, and their prevention, in connection with vessels containing fuels capable of producing rapid expansions or explosions when mixed with the proper amount of air.

When a gas line, holder, or tank containing inflammable gas or fluid is opened to the atmosphere, allowing air to enter, an explosive mixture will result. Likewise, if the gas line, holder or tank contains air and an inflammable gas or fluid is introduced, an explosive mixture will be present.

In order to eliminate the fire hazard when it is necessary to open vessels containing inflammable materials, it is recommended practice to purge such apparatus with an inert gas, to the point where the resultant mixture is non-explosive when mixed with air in any proportion.

Before going further with this section, I would like to call to your attention a few of the terms used in connection with purging.

Lower limit of inflammability or lower explosive limit of a combustible gas or vapor, is the lowest concentration of the gas or vapor (in air) that will burn without the continuous application of heat from an external source.

Upper limit of inflammability or upper explosive limit of a combustible gas or vapor is the highest concentration of that gas or vapor (in air) that will burn. Above

the upper limit the large amount of combustible gas acts as a diluent and combustion cannot be self-propellant.

The explosive limit is the concentration of a combustible gas or vapor between the lower and upper limits of flammability.

The propagation of flame in a inflammable gas-air mixture is a term used to designate a flame passing through a combustible gas mixture and caused by actual burning of the gas; the speed of flame propagation is the rate at which a flame will propagate through a combustible gas mixture. This rate varies with the concentration of and the type of gas. In general, the highest speed of flame propagation is encountered at approximately the theoretical gas-air mixture necessary for complete combustion.

The end point is the point at which a mixture of the inert combustible gas mixture plus air will not burn under any provocation.

An inert gas is a gas that will not enter readily into chemical reaction and is therefore, not combustible. It is dangerous only where it is allowed to drop the oxygen content of an atmosphere below the point where a man may work safely (about 16 per cent).

The inert gases commonly used for purging are nitrogen, and carbon dioxide, or a mixture of the two.

One of the simplest and easiest ways of purging short lines or small vessels is to use nitrogen or carbon dioxide from bottles. Each bottle or cylinder contains about 300 cu. ft. of gas and is usually sufficient for purging about 250 ft. of 12 in. line. Nitrogen is not quite as efficient as carbon dioxide. On the other hand, carbon dioxide is more difficult to handle due to the freezing of regulators and gauges when it is discharged from the bottle. Because the regulators do freeze, a special regulator must be used with carbon dioxide while only an ordinary oxygen regulator is required for nitrogen.

When using bottled inert gas and purging from air to gas, the only test necessary is one which will give an indication of the oxygen content of the mixture leaving the extreme end of the line being purged. This can be done with an orsat apparatus. The oxygen should be brought down to 3 per cent or less. In going from gas to air, a combustible gas indicator must be used.

In purging long lines or large vessels, a machine is used to manufacture the inert gas. This machine consists of a burner which can burn gas or oil, usually gas. The products of combustion are cooled and pumped into the vessel to be purged. Frequent orsat readings must be taken of the products of combustion, to keep the carbon monoxide and oxygen content as low as possible. The ideal condition would be to have no oxygen or carbon monoxide present, but as this cannot always be done, it is preferable to keep a very slight excess of oxygen to make certain that all the combustible gas is burned. The maximum safe limit is 2 per cent oxygen and 0.2 per cent carbon monoxide.

The same tests on the vessel being purged can be used as outlined for bottled gas.

Sometimes the exhaust of an internal combustion engine is used as a source of inert gas. When this is done a number of precautions must be taken.

First, orsat readings of the exhaust should be taken, and a mechanic should change the carburetor to keep the carbon monoxide content at a minimum.

Second, the exhaust should be discharged through a water seal to quench all sparks.

Third, while a positive pressure must be kept in the vessel being purged, back pressure on the internal combustion engine must be kept as low as possible.

Fourth, the water seal should also act as a cooling agent for the exhaust gas. A continuous supply of cold water should therefore be available.

Fifth, after the combustion of the engine has been regulated as desired, orsat readings should be taken at frequent intervals as a check on the setting.

Sixth, the engine speed should be kept constant to eliminate possible setting changes.

The same tests on the purged line can be made with this type of purging as with bottled gas.

Another source of inert gas for purging is de-oxidizing gas machines. By adjusting a gas machine so as to have completely burned gas, an inert gas is available which can be piped to wherever it is convenient.

When purging a line from air to inert gas to combustible gas, it has been pointed out that the only test necessary is with an orsat, in order to determine the oxygen content of the air-inert gas mixture.

When purging a line or vessel which contains a combustible gas, tests must be of the type where a portion of the combustible inert gas mixture is actually burned, and they should be continued until the end point is reached.

There are acceptable combustible gas indicators for this service on the market. In operation, the indicator utilizes the effect of combustion of inflammable gas air mixtures on the surface of a glowing filament. This combustion increases the temperature and consequently the electrical resistance of the filament circuit, causing the needle of a meter to move over its scale. The scale is calibrated to read per cent explosibility, assuming that all lower explosive limits are 100 per cent explosive.

In operation, a sample is aspirated from the testing location and drawn through the combustion chamber which contains the active or testing element. Here it burns upon the glowing filament wire, causing the change in resistance when inflammable gases are present. At the start of the purging operation the gas valve to the instrument is barely opened and the air dilution valve is left wide open. The meter reading will probably be off scale, indicating a high concentration of combustible gas. As purging progresses more gas is allowed to enter the instrument until a point is reached where full opening of the gas sample valve and various air valve settings do not read over 5 on the scale. This indicates that the atmosphere contains a nominal amount of inflammable gas and is considered non-inflammable but toxic.

It is highly desirable to check an apparatus of this kind with an orsat during purging operations, as a safeguard against the instrument being off calibration.

Very often a sample from the vessel being purged is trapped in a bomb, removed to a safe distance and then ignited. Naturally, if it does not burn further purging is unnecessary. This is not recommended as it is bad practice.

All gas-air mixtures have a definite explosive range, depending chiefly upon the relative percentage of gas-air present in the mixtures. At either end of this explosive range lies a gas and air mixture that will not explode

under any provocation. Theoretically then, all of the gas need not be purged from the apparatus before air can safely be turned into it. The question next arises as to how long purging must continue.

As we know, the two explosive limits of a combustible gas have a very definite and characteristic value. The factors involved in the explosion are, however, so complicated that no one has yet devised a satisfactory method for their accurate prediction and the values have to be experimentally predetermined in a suitable laboratory apparatus.

If the combustible gas is diluted with some inert gas, the explosive limits of the mixture in air is changed. The change depends upon the nature and the amount of the inert gas added, but the direction and the degree of the change are unpredictable by any method yet known, and must be experimentally determined. In general, the lower limits of such mixtures are raised with increased dilution with inerts, but the upper limits may be either raised or lowered and may even be raised in the presence of one inert and lowered in the presence of another. The limits of many gases are narrowed by dilution with an inert gas but the limits of some are widened, the differences between them being even more than doubled in certain cases as the dilution by inert gas is increased. The effect of each diluent must be separately investigated.

We know that all the gas need not be purged from a vessel to make it safe, but, as we do not know where the safe end point will be in the diluted gas-inert mixture, it is good practice to over purge until the gas indicator tester shows no explosive gas present. Another good check is to continue the purging until the purge vapors contain less than 1¼ per cent of combustible gases. This avoids all technicalities and is even better than safe practice.

There are a few points to bear in mind during and after the purging operation.

1. Always keep a positive pressure on the line or vessel being purged.

2. Be sure all water is drained from drips, etc.

3. Before allowing anyone without a gas mask to enter the purged container, it must be thoroughly aired until free from toxic gases and oxygen deficiency.

4. In purging coke oven gas lines, oil tanks, benzol scrubbers, etc., where light oil is present, it will be difficult to reach an end point because of the tendency of the oils to continue to vaporize. This is especially true in wooden grid scrubbers or cleaners, which have absorbed a large quantity of oil. If after draining and cleaning as well as possible, a satisfactory end point cannot be reached, then purging with steam must be resorted to.

5. The incoming gas line should be sealed off at the end of the purging cycle. When men are to work inside a line or vessel that has been in gas service, a positive seal or blank should always be installed.

6. When purging from air to inert gas to combustible gas, be sure that all of the inert combustible gas mixture is bled from the line before the line is put into burning equipment service.

7. When bleeding a gas line etc. of combustible gas or inert gas or mixtures of either with air, the bleeding should be done through an approved fire check.

All the data and information which follows is taken from technical papers published by the American Gas Association, and written by R. E. Kruger, superintendent of gas manufacturing, Rochester Gas and Electric Company, and J. S. Yeaw and Louis Shnidman, also of the Rochester Gas and Electric Company.

In their study of the extinction of gas flames by steam, Yeaw and Shnidman found that in almost all cases, steam was found to be equivalent to and in some instances superior to inert carbon dioxide in its quenching effect on flame propagation. Nitrogen was found to be much weaker than either steam or carbon dioxide.

As an example, experiments conducted with manufactured gas of 538 Btu. showed it required 10.8 volumes of nitrogen, 6.0 volumes of carbon dioxide, but only 5.3 volumes of water vapor per volume of combustible to render all mixtures of manufactured gas and air non-inflammable.

As pointed out by Kruger in his paper, a very notable example of the effectiveness of steam purging appears each time the base of a water gas generator is purged by steam after a down run and prior to going into a blasting period. Each time the operator neglects to purge the blue gas from the base of the generator with steam, an explosion occurs.

One of the drawbacks of steam purging is the difficulty in determining when an end point is reached, or in other words, to know definitely when the purging operation is complete.

When we put steam under slight pressure into the vessel being purged it will force out the gas, a matter of direct displacement, and soon both steam and gas will be leaving the exit vent. Now steam when cooled to atmospheric temperatures will condense to water, but air and gas at the same temperature will not condense. Therefore, if a sample of the exit gas and vapors is trapped and condensed, a direct indication of the proportion of steam-gas mixture will result.

A steam purge indicator has been developed which is similar in operation to an ordinary orsat sampling tube and bottle. The sample is trapped in the tube and then condensed by the water in the leveling bottle. Steam is condensed to water so the balance of the sample must be gas.

If the sampling tube fills completely with water, then no gas is present in the purge vapors. When the purge vapors have been brought down to less than 1¼ per cent gas, it is safe to consider the purge complete.

As was pointed out in an earlier paragraph, it must be remembered that in all purging operations where light oils, naphthalene, sludge or other volatile materials are present, the purging operation is not complete until this material has been bodily removed or "topped." The complete elimination of oil from an apparatus like a light oil scrubber with soaked wooden grids is hardly possible with inert purging alone. As the rate of volatilization of the oils is largely a function of temperature and as steam supplies this temperature it follows therefore, that steam is the logical purging agent for this type of work. In an apparatus where light oils are present, it is very likely that all gas will be purged from the vessel long before all the light oils are vaporized. When this is the case, purging must continue until less than 5 per cent of the condensate is oil. When steam can no longer volatilize 5 per cent or more oil, then air at atmospheric temperature cannot volatilize that oil

and the apparatus is ready to be opened to the air.

The following method is recommended for measuring the oil condensate.

An ordinary condensing coil of about 20 ft. of ¼ in. copper tubing is attached to the exit where the purge readings were taken. The purge vapors, consisting of steam and oil vapors, are condensed and caught in an ordinary 100 cc. beaker. The water of course will settle to the bottom and oil at the top. Presumably steam may be shut off when the sample reads 5 per cent but it so happens that there is not a direct relationship between the amount of steam passing through the apparatus and the amount of oil being removed. For this reason we change the steaming rate by cutting it in about half and take another series of samples. Unless the apparatus is completely purged the percentage of oil will increase.

The reason behind this increase in oil is that in cutting the steam flow, temperature and pressure of the light oils is only slightly changed so volatilization should continue at about the same rate and the amount of oil condensate should remain the same. However, as considerably less steam is used, the water condensate should be materially decreased. Our 100 cc. sample will therefore show a higher percentage of oil if purging is not complete.

When the check sample again shows 5 per cent or less oil, the steaming rate is again decreased. This procedure is continued until a point is reached when steam can no longer volatilize 5 per cent or more oil. As stated before, air at atmospheric temperatures can certainly not volatilize that oil either.

The use of steam as a purging agent can be recommended where the higher temperatures are necessary or are not objectionable.

It should not be used in cast iron mains or long pipe lines, complicated headers, boosters or machines with close clearances. The effect of its higher temperatures with the resultant expansion should be carefully considered. Also large holders or apparatus with large condensing surfaces are poor subjects for steam purging.

In general, steam is good purging agent for the following reasons:

1. Large direct displacement.
2. Distillation of vapor phase oils.
3. Wash down due to condensate.
4. It is usually available in large quantity.

It is not a good purging agent because:

1. It is difficult to determine the end point.
2. High temperature with resultant expansion may cause strains or flange leaks.
3. Condensation is high on large vessels requiring an excessive amount.

In a previous paragraph of this section it was stated that the only accurate method of determining explosive limits of mixed gases was laboratory burning determinations. However, when the chemical analysis of a mixed gas is known both the upper and lower explosive limits may be calculated. Experiments conducted by U. S. Bureau of Mines with simple limit gas mixtures showed that calculated values checked fairly closely with observed data, but that complex mixtures varied up to 5 per cent. It was also difficult to repeat an experiment and arrive at the same results. The obvious conclusion, therefore, is that the point at which a gas mixture is non-inflammable will vary over 5 per cent of the calculated lower limit range and to be on the safe side it is better to over-purge than to under-purge.

Attention is called to the fact that no mention has been made of purging by allowing a combustible gas to force air out of a new gas line, a method commonly called air purging. This method should be discouraged because it is impossible to go from air to gas or gas to air without the mixture passing through both the upper and lower inflammable limits with the resulting explosive hazard.

Gas accumulations in buildings, due to leaks or broken lines, can be exceedingly dangerous. Several bad explosions have resulted from this cause in recent years. In cases of light gases containing a considerable amount of hydrogen, the gas collects near the roof of the building and cannot be detected at the floor level. When a gas accumulation is known to exist in a building, care should be taken to prevent any ignition taking place, even from the floor levels, all people should be removed from the building and sufficient time allowed for the building to clear by means of natural draft.

PART II—CARBON MONOXIDE AND ITS DETECTION

By J. S. MORRIS

If Lucretia Borgia, the famous poisoner of the middle ages, had known what scientists know today, instead of using the gastronomical route for the extinction of her enemies (a method, by the way, which was effective in most cases, though not as humane as it might have been) she would have used an easier, more effective and refined method; namely, the inhalation route. This may readily be seen when one considers that a person eats only three times per day while he takes an average of eight thousand full breaths each day. In food poisoning some time elapses before the effect of the poison is felt throughout the system, but all poison that is breathed in is absorbed immediately and rushed over the system in less than a half a minute.

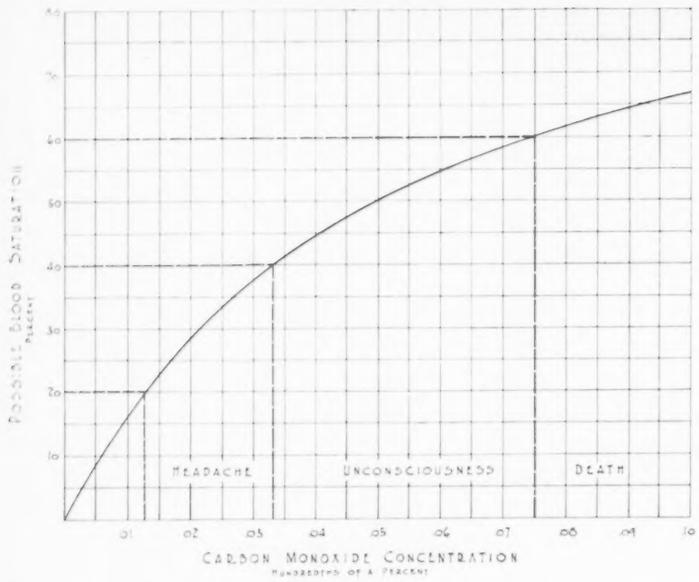
In combating the hazards of poison gas it is first necessary to list all materials or combinations of materials used or produced, whose resultant fumes may cause sickness or injury to the respiratory system.

In our own steel industry the dangerous gases are limited mainly to carbon monoxide. Carbon monoxide is a gas formed wherever there is incomplete combustion of carbon.

Carbon monoxide was first prepared by Lassone in 1776 by heating zinc oxide and carbon, and was thought to be identical with hydrogen, but Cruikshank, Clement, Desormes in 1801 showed that it contained only carbon and oxygen. In 1803 Dalton proved that it contained only half as much oxygen as carbon dioxide.

It is a colorless, odorless gas having a density of 0.967 (air being taken as 1) and is not easily liquified. Its boiling point is minus 190 degrees C., its critical pressure 35.5 atmospheres, and its melting point is minus 200 degrees C. It is only very slightly soluble in water. In all the above physical properties it shows a remarkable resemblance to nitrogen—a matter of interest in view of the electronic structure of the two molecules.

Carbon monoxide burns readily with a pale, blue



Blood Saturation Resulting From Exposure to Various CO Concentration Showing the Constitutional Effect on the Average Person.

FIGURE 1

flame, giving the dioxide, but in dry air its burning is retarded.

Carbon monoxide will be found in varying quantities around open hearth furnace tap holes, blast furnaces, blast furnace stoves, gas mains, and garages which are slightly enclosed. At any one of the previously named places concentrations sufficiently strong to cause death may be found. Small leaks in a closed building are as dangerous or more so than large leaks outside.

Gases containing carbon monoxide are used in the steel plant for heating purposes. Therefore, it is pumped to all sections of the plant, creating plenty of opportunities for contamination of the air in various shops.

The following percentage of carbon monoxide is found in the following gases:

	Per cent CO
Blast furnace gas	27.7
Bessemer gas	25.0
Open hearth tap hole	27.0
Gas from cupola	17.0
Coke oven gas	5.9
Mixed coke oven gas and blast furnace gas	8.1
Exhaust from automobile	7.0

In spite of the many cases of carbon monoxide poisoning which have occurred in industry, it is hard to state what percentage of contamination is dangerous. According to Haldane discomfort begins at about 0.02 per cent. Since discomfort begins at such a low percentage it is reasonable to believe that 0.2 to 0.3 per cent contamination would result in asphyxia to a degree that would endanger life. Certainly a continued exposure to such an atmosphere would result in the blood stream becoming saturated beyond the point that life could be maintained.

According to some writers the term "carbon monoxide poisoning" is not correct, nor is it correct to refer to monoxide as a poison gas because it is physiologically inert. Its action when breathed is to rob the red corpuscles of their supply of oxygen. Carbon monoxide really causes an asphyxiation within the elements of the blood stream. The blood of humans is so compounded that the hemoglobin of the red cells have an affinity for carbon monoxide three hundred times greater than for oxygen. Upon uniting with the hemoglobin of the blood it forms carboxyhemoglobin; the chemical reaction between carbon monoxide and the red corpuscles also hardens the cell for the rest of its life. In autopsies performed on people who have died of monoxide blood saturization, the internal organs showed fatty degenerations. Haldane says as a result of his experimental work that 20 per cent of saturation of hemoglobin with CO will cause dizziness, 50 per cent unconsciousness and 80 per cent death.

Figure 1 gives the saturation resulting from exposure to various CO concentrations, showing the constitutional effect on the average person. The curve shows that exceedingly small amounts of carbon monoxide are dangerous for workmen. A concentration of only two parts in 10,000, or 0.02 per cent, may produce a headache in less than an hour and unconsciousness in two hours, while 0.1 per cent carbon monoxide will prove fatal in approximately four hours, depending upon the per cent of saturation of the blood. This fact cannot be stated too strongly. Exposure to minute concentrations of carbon monoxide, over a sufficient period of time, can produce exactly the same toxic effect as a short exposure to higher concentrations. The poison is steadily cumulative, up to the limit of blood saturation attainable with the existing concentration of the gas. Approximately half of the possible blood saturation is attained in the first hour of exposure, half of the remainder in the second hour and half of the remainder in the third hour, etc.

Figure 2 shows carbon monoxide absorption by human blood as the hours of exposure increase and the results of such exposure. The six curves represent different concentrations in hundredths of a per cent. For instance, let us take curve No. 5 (from the bottom) which represents air containing sixteen parts of carbon monoxide per ten thousand parts of air (or 0.16 of a per cent). A person breathing such atmosphere would be in the region of impaired judgment after an exposure of three quarters of an hour; in the region of collapse or unconsciousness after an hour; and in the region of probable death after one and a half hours' exposure.

The action of carbon monoxide is increased by heat, exertion, and humidity. Young men are more susceptible than old men (one writer says this is probably due to the fact that young men breathe deeper). Just as alcohol's effects vary with different people, so does carbon monoxide react differently. Naturally the degree of concentration of the gasified atmosphere and the per cent saturization of the blood stream, coupled with the susceptibility of the patient, will determine the velocity of the reaction. In small concentrations the symptoms in their increasing order are as follows: severe headache; dizziness; and pains in the stomach coupled with a feeling of weakness and nausea.

In medium concentrations the above symptoms follow in rapid succession and unconsciousness develops quickly. Such a patient may be removed to good atmos-

phere and revived through artificial respiration, chances of revival being enhanced if oxygen in concentrated form is bled near patient's nose. Unconscious patients may or may not be breathing depending on the depth of their coma, but if the heart is still beating they can be revived. Often the patient will be in such a deep coma that the average person will be unable to detect any pulse or heart beat. The heart however may be puslating very weakly and if so the patient may be revived. Respiration should be applied in any event until a bona-fide physician has pronounced the patient dead.

The symptoms of a gased and unconscious patient follow: complete muscular relaxation; bluish face and pink lips; labored breathing (perhaps no visible signs of breathing); red splotches on face or body due to hemorrhage under the skin; and convulsions and twitchings during unconsciousness.

Some plants have become "safety minded" and wherever this is true, steps have been taken to prevent loss of life. All known safety regulators, signals and other devices are used. These under some circumstances however prove inadequate and so it has become necessary for safety's sake to find some means of quickly detecting carbon monoxide and other poisonous gases which will prove injurious or fatal to workers.

Companies working in conjunction with the U. S. Bureau of Mines have developed methods of detecting minute traces of carbon monoxide. The safety appliance companies have a number of carbon monoxide detectors ranging from indicators to warning alarms. Time will not permit a discussion of these instruments.

The simplest one of these for use in and around sewers is the carbon monoxide ampoule detector, which is sensitive to concentrations as low as 0.05 per cent; they are not suitable however for use at low temperatures. The ampoule detector consists essentially of palladium chloride in an acetone-water absorbent cotton (similar to the ammonia capsules in use for first aid). The ampoule is crushed between the fingers and suspended by a string in the questionable atmosphere for a period of ten minutes. In the presence of carbon monoxide the cotton turns dark and is compared with a chart graduated in shades of gray in order to determine the degree of danger.

Another and perhaps more accurate detector is known as the hoolamite machine. It is a very simple and quick-acting instrument, only ten seconds being required to make a test. Its accurate range for determining concentrations is from 0.05 per cent to 1.0 per cent. By squeezing the bulb, air is forced into the detector tube through a barrel filled with "gasorbent," a preparation which removes any foreign material that may affect the reading. The detector tube is filled with "hoolamite" (a specially prepared chemical consisting of fuming sulphuric acid and iodine pentoxide impregnated on pumice stone) which changes color from grayish-white to a shade of green that varies in depth with the amount of carbon monoxide present. The color is compared with a color scale mounted by the detector tube, graduated to read concentrations up to one per cent carbon monoxide.

There is another type of carbon monoxide indicator which is used to detect extremely low concentrations of carbon monoxide and is known as the "hopcalite" indicator. The chemicals used in it and their reactions were discovered by two professors, one from Johns Hopkins University, the other from California—hence the trade name of hopcalite.

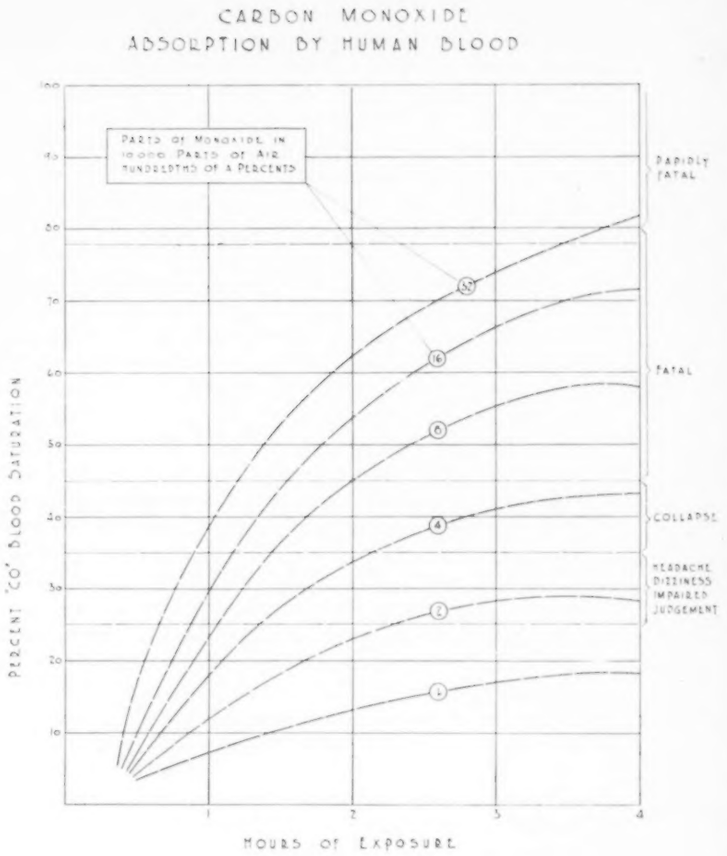


FIGURE 2

The method of operation and description follows: A small motor driven pump draws the sample continuously into the instrument. The sample first passes through a flowmeter, consisting of an orifice and manometer, used to maintain a constant flow.

This is accomplished by having a constant differential on the manometer through the adjustment of the volume control valve. The sample then passes through a dehydrating canister which removes any moisture. From the canister it enters the cell containing a catalyst known as hopcalite, and then passes out the exhaust valve of the pump. In the cell, any carbon monoxide is oxidized to carbon dioxide, by the catalytic action of the hopcalite. Heat, liberated by this oxidation, is directly proportional to the amount of carbon monoxide present and is measured by a series of thermocouples in series with the indicating meter. The meter is calibrated to read directly in percentage of carbon monoxide and has a scale graduated from 0 to 0.15 per cent carbon monoxide graduated in hundredths of a per cent. It can be read directly to 0.005 per cent and estimated to 0.001 per cent (1 part CO to 100,000 air).

The warning alarm takes continuous samples of the atmosphere in the working place and when carbon monoxide concentrations reach 0.02 per cent, a point

of minimum danger, the alarm is set off. The alarm must be shut off manually, assuming that the alarm will be heeded and ventilation changes made.

Another machine, the all-service gas indicator, will quickly detect the percentages of combustible gas present, the carbon monoxide and hydrogen sulphide concentrations. Only its operation in detecting carbon monoxide will be described. The toxic chamber flame safety lamp assembly is attached to the combustible gas indicator, enabling the operator to detect the presence of carbon monoxide in concentrations as low as 0.05 per cent. In the toxic chamber the carbon monoxide reduces a palladium chloride solution by precipitation of a fine black powder. A piece of specially treated absorbent paper upon which a few drops of palladium chloride have been sprinkled, is suspended in the toxic chamber. The treated area gradually darkens and turns black in the presence of carbon monoxide. The aluminum housing around the electric lamp conducts the heat from the lamp to the chamber, speeding the reaction. The time required for the reaction depends upon the temperature of the sample and the outside temperature, but above 40 degrees F. the time will be about 8 min.

As heretofore pointed out some people are more sensitive to minute concentrations, becoming sick after exposure. It is erroneous to say that some persons have a natural or acquired immunity to carbon monoxide. Repeated exposures create the same identical physical reactions. Some medical authorities believe that after repeated exposures to small concentrations the reactions become chronic, and much intensified in their effect.

Despite the research work done to make carbon monoxide detection simple, casualties are still too high. Statistics show that CO now ranks fourth as a cause of deaths reported to the coroner's office. The U. S. Census Bureau figures that deaths from carbon monoxide poisoning have increased more than 400 per cent since 1924.

The above statistics are appalling, and show that greater care should be taken where there is a possibility of monoxide poisoning. Any tests are valueless if men are forced to work in the atmosphere the first minute there seems to be a possibility of their doing so safely.

When necessary to work around gasified atmospheres all possible precautions should be taken. The foreman should know his men and their physical condition.

The concentration of carbon monoxide should be determined by some instrument. When it is known the foremen should consider the time element of the exposure of his men, since small concentrations over a long exposure are just as dangerous as large concentrations over a short period.

PART III—OPERATION OF GAS SAFETY REGULATORS

By D. G. HISLEY

The use of gaseous fuels in a steel plant requires an adequate system of safety regulators. The importance of these regulators will be appreciated when one realizes the numerous and diverse uses of gas in present day steel plants.

The prime function of gas safety regulators is the elimination of the explosive mixture hazard, by maintaining a positive pressure in all lines up to the point of consumption. These regulators are designed to shut off the gas supply to the consumer when the quantity available is not sufficient to maintain the required line pressure. Electric power failures and erratic blast furnace operation are two of the chief causes of gas supply failures.

Safety regulators do not operate very often, but they must always be maintained to function when necessary. In view of this fact, the best type of safety control is a combination pressure and safety regulator. This general type consists of a double diaphragm top connected by a balance arm. One top controls the line pressure during normal operation, the other assuming control of the regulator motion if the supply gas pressure becomes less than any predetermined minimum.

A regulator of this type being constantly in operation has very little chance of failing to operate in an emergency. A regulator whose sole function is operation in event of gas supply failure, must be thoroughly checked at frequent intervals in order to be sure of its readiness to operate in emergency.

At this point it might be well to mention that all gas safety regulators should be installed so that the operators, when testing, can cause the same action on the pressure element that takes place when there is a failure in the gas supply.

There are, in general, five types of safety or combination safety pressure regulators. The proper unit for any individual installation depends on the type of protection desired as well as the speed of operation.

In the following paragraphs, a short discussion of these general types of controls will be presented.

1. The electric safety regulator is nothing more than an electric switch, operated by a pressure element. The switch may be either a metal contact or a mercoid type. In general, they are set either to open or close an electric circuit when the gas supply pressure becomes lower than desired. The pressure at which the control operates is adjustable and this setting is determined from the minimum pressure required for safe operation of the unit using the gas.

This type of control when kept in good condition, is very satisfactory for use in gas pressure failures. However, in event of power failures it is not as positive, unless used to open the circuit to the controlled valve. When used in this manner, the electric circuit is closed during normal operation. Thus, in case of either gas supply or power failure, the control will function as a safety regulator.

2. The hydraulic safety regulator, generally, requires oil pressure for operation. This regulator consists of one or more diaphragms with a distributing or pilot valve for transmitting the oil pressure impulse to the power cylinder. The oil pressure is usually supplied by separate electric driven oil pump units. Unless these pumps are equipped with a steam driven auxiliary unit the hydraulic regulator is useless in event of electric power failures. In some installations it may be possible to counterweight the valve being operated, so that it will function as a safety control during electric power failures. However, this type of control is not positive enough for most purposes.

3. The air regulator is similar in operation to the

hydraulic type except that air is used for the motive power in place of oil. It is subject to the same limitations in event of electric power failure. However, it is usually possible to provide an air receiver to insure sufficient air supply in case of power failure.

4. The air-hydraulic regulator as used for a pressure regulator consists of a pressure element, an electric element, and an oil power element. In the pressure element, gas pressure is applied to the upper side of a diaphragm. This diaphragm balances against air loading on the bottom and controls a pilot valve which supplies air pressure to either of two oil filled containers in the base of the regulator. The air pressure forces the oil to the power cylinder. In event of low gas pressure, a pressure switch is tripped, which through an electric relay, closes a solenoid valve in the gas pressure line to to the pressure element. Simultaneously, another solenoid valve opens a by-pass to each side of the diaphragm. As the pressure is equalized, the diaphragm drops, causing the power cylinder to close. As this type of regulator requires air pressure for operation, it becomes essential to provide a suitable receiver for use in case of air failure.

5. A gas holder is a large tank used for storing gas. Although primarily a pressure regulator, the gas holder has several features which make it useful as a safety control. The holder is usually provided with a signal system to warn consumers when the holder is approaching a predetermined low point. By this means a sufficient reserve capacity is provided so that various users have time to reduce consumption or shut down completely, depending on the nature of the emergency.

Blast furnace gas leaving the furnaces passes through the primary tower washers and is delivered to the raw or dirty gas mains containing approximately 0.3 grains of dust per cu. ft. Without further cleaning this gas may be used under the boilers and in the furnace hot stoves. However, most of it is subject to further cleaning in central stations from whence it is delivered to soaking pits, gas-electric and- blowing engines, underfired coke ovens and mill mixing stations.

Whether raw gas or cleaned gas is used, the blast furnace hot stoves require a combination pressure safety regulator. The air-hydraulic regulator, eliminating the need for oil pump units, is preferred for this installation. An air receiver large enough to supply the regulator for approximately 15 minutes is used to permit operation in case of air failure.

On boiler combustion control oil has been found ideal as the source of regulator power. The oil hydraulic combination safety pressure regulator has proven very satisfactory for boiler house service. Although the oil pressure is usually supplied by an electrically driven pump, a steam driven pump is provided, which starts automatically in case of power failure.

For central cleaning stations employing electric power driven cleaners and boosters, a pressure regulator is required to control the pressure of the clean gas leaving the station. It is also most important to prevent the machines from creating a suction in the raw gas inlet mains. These two functions are ably provided for by the hydraulic regulator equipped with a double diaphragm top. This regulator receives its power from electrically driven oil pumps. Usually, no alternate power is provided, as a power failure would also shut down the boosters, thus eliminating the possibility of creating a suction in the raw gas main. These systems are so arranged that the speed of the booster is reduced first while the regulator valve finally closes if the raw gas pressure continues to decrease.

Gas blowing and electric engines as well as underfired coke oven batteries using cleaned blast furnace gas should always be equipped with a gas holder, providing large enough reserve capacity to insure a constant gas supply at all times.

The gas blowing engines should have priority in all instances. Other units are provided with an alternate fuel for use during periods of low blast furnace gas pressures. Boilers equipped for both oil and gas firing are the most logical units to provide the so-called fly wheel action. When an excess of blast furnace gas is available they use the surplus; during periods of gas shortage, the alternate fuel is used.

The gas obtained in the coke making process, after by-product recovery, is delivered to gas holders. The holder supplies gas for underfiring and the gas pumping stations.

At the gas pumping stations coke oven gas from the holder and blast furnace gas from the central cleaning station are mixed in any desired proportion and pumped to the various mills throughout the plant. At these pumping and mixing stations it is important to provide means for preventing the pumps from causing a suction in the inlet mains.

Reciprocating pumps are usually provided for gas pumping. Each pump has several by-pass valves between the discharge and suction sides. Compressed air is used as loading to keep these valves closed during normal operation. When low gas pressures occur in the inlet coke oven gas main, an electric regulator shuts a solenoid valve in the air supply line to the by-pass valves. The loss of air pressure causes the by-pass valves to open, thereby reducing the output of the pump. In the blast furnace gas inlet main an electric safety regulator closing a weight loaded butterfly valve is used. In event of blast furnace gas failure straight coke oven gas is sent to the mills due to the closing of the blast furnace safety regulator. If the coke gas fails the pumps unload, thus preventing low Btu. gas from being sent to the mills.

The mixed gas as sent from the pumping station is piped underground to the various mills throughout the plant. In each of these mills both safety and pressure controls are required depending on the type of consumer.

At the mills where gas is consumed at the pressures as delivered from the pumping station, a combination pressure and safety regulator is desirable, but not essential. In some cases a pressure regulator and a warning siren to operate on low main gas pressures are are sufficient. All of our automatic control systems for fuel fired furnaces are air operated. This is, in effect, a safety control in respect to power failures. In event of an electric power failure, the consequent loss of compressed air automatically shuts the fuel off.

In the mills where the gas is supplied to premixed gas machines it becomes necessary to provide a safety control in order to prevent the boosters from pulling a suction in the main supply lines. The electric mercoid type is used on these machines. The switch is set for a

predetermined low point such as 2 lb.; when the main line pressure reaches this point, the booster is automatically shut down.

In our soaking pits where the blast furnace gas and coke gas are delivered separately and mixed in the desired proportions, several types of safety controls are required.

The blast furnace gas main line is provided with an air hydraulic pressure safety regulator. When the supply of blast furnace gas is low a pressure switch closes this regulator; at the same time it de-energizes solenoid valves in the air lines to the individual gas valves at the pits. These individual valves are held open by air pressure and the solenoids are open when energized. Therefore, in case of either power or air failure the fuel is shut off the pits. In case of low coke gas, the booster is shut down by means of a pressure switch, allowing the pits to operate on straight blast furnace gas.

In all gas fired systems it is well to have warning signals in addition to safety controls. On systems capable of causing a suction in the main lines, it is also better to have two different types of safety controls.

In addition to their primary function, safety controls also have a distribution function. By adjusting the pressure at which the various controls shut off the gas supply, we are able to eliminate one consumer in preference to another. Mills and boilers where more than one fuel is available are shut off first, thus keeping the single fuel gas furnaces and gas engines operating as long as possible. If the gas shortage is to last for any length of time, several of the large consumers of gas are changed over to oil firing.

PART IV—SAFETY AND THE BURNING OF BLAST FURNACE GAS

By C. E. DUFFY

The use of blast furnace gas in a steel plant is one of its vital by-product functions. The gas is usually used in equipment such as boilers, gas engines, blast furnace stoves, soaking pits, etc. This equipment may well be described as the heart of the plant, where continual operation is vital.

Inasmuch as blast furnace gas is particularly explosive under certain conditions, the safe handling of this commodity requires much thought and respect.

A typical analysis of blast furnace gas is as follows:

	Per cent by volume
CO_2	12.2
O_2	Nil
CO	27.7
CH_4	.2
H_2	2.6
N_2	57.3
Btu.	98.5
Specific gravity	1.01

The application of blast furnace gas to various consuming units of a steel plant probably requires more thought to insure a safe practice than any other fuel used. This is due to the following major characteristics of blast furnace gas:

1—Poisonous Effect

As noted from the analysis, blast furnace gas contains nearly 30 per cent of carbon monoxide, a deadly poison. Since blast furnace gas is practically odorless, it is important that all gas lines and furnace settings be kept tight at all times.

2—Specific Gravity

Blast furnace gas has approximately the same specific gravity as air, thus, when bled or leaking into the atmosphere, it does not rise as would a lighter gas, but mixes with the air in the vicinity where the leak or bleeding occurs. For this reason all gas bleeders should be opened high above the ground and away from areas where men have to work. Buildings where blast furnace gas installations are made should be provided with good ventilation. It is important that no one be allowed to enter alone into semi-closed places such as cellars of soaking pits and gas engine buildings, where good ventilation is not possible.

If a gas leak of sufficient intensity to set up an explosive mixture should develop in a poorly ventilated area, forced ventilation should be provided to clear the area where the explosive mixture occurs. While this is being done, care must naturally be taken to make certain that no equipment that will ignite the explosive mixture is operating in the gas area. If electric fans or blowers are used, these should be operated on the windward side of the building.

3—Calorific Value

Blast furnace gas has a low Btu. or heating value. Due to this fact it is necessary to provide all consumers with large quantities of gas. When a cold furnace is put into operation with blast furnace gas it is necessary to provide sufficient pilot flame to insure ignition. In blast furnace stoves, a wood fire in the combustion chamber serves the purpose until the brick-work reaches a temperature of approximately 1200 degrees F. In steam boiler operation, permanent pilot burners must be provided to maintain ignition. This is especially important for boilers equipped with water-cooled walls, or boilers equipped for operating on two fuels. Fuel oil makes a satisfactory fuel for pilot burners on steam boiler installations.

With a reversing furnace a different problem is encountered. Since this type of furnace must be reversed periodically and as the reversing operation is usually done automatically, one can readily see that pilot burners would be unsuitable for this operation. Hence, when a reversing type furnace is to be put into operation, it is best to use a high Btu. fuel until the furnace and regenerators are hot enough to insure ignition at all times. This practice serves two purposes as follows:

(A) It insures immediate ignition when gas is turned into the furnace. This is important because the furnace has been equipped with large gas burners. If the gas does not ignite immediately when one of these burners is opened, the furnace setting will soon be filled with an explosive mixture. Then when ignition does take place, an explosion will result which may be disastrous.

(B) By heating the checkers before turning blast furnace gas into the furnace, we are able to supply preheated air for combustion, thus obtaining a higher flame temperature which in a short time will bring the furnace to an operating temperature.

PART V—SAFETY PROCEDURE IN GAS-FIRED FURNACES

By J. F. BLACK

We approach the subject of safe practice in the lighting and firing of gas furnaces with the admonition which is loosely applied to various operations throughout the plant, but which is particularly appropriate to this subject, namely, "Think."

With exception of a munitions factory or a hydrogen manufacturing plant, the handling of gas in an industrial plant probably presents more potential dangers than any other line of work.

In a new installation the gas lines to the furnaces should be inspected from the source of gas to the furnace, making sure that all outlets are properly closed. It should be ascertained whether erectors have tested the lines for defects and leaking joints. No gas should ever be put into a line until it is tested and purged satisfactorily.

With a new furnace, or a furnace with a considerable amount of new brick work, it is customary to burn wood slowly on the furnace hearth to drive out some of the moisture and warm the bricks. If the furnace has forced draft, the fan should be run for 15 min. before any fires are lighted. This is good practice and a safe one. Care should be taken not to build large fires, however, lest the furnace be damaged, especially the roof. As a further aid, it is well to build a fire of modest proportions, in the stack, to insure a good draft.

An open wood fire should be built on the hearth of the furnace just in front of the burners that are to be lighted.

Choose a burner at the end of the furnace gas header near the operating door to start the light-up. Place the furnace on hand control. Never light a furnace on automatic control.

Case 1—If the furnace is fitted with low pressure gas burners, go through the following procedure:

1. Make an inspection of the furnace and burner equipment to ascertain that all equipment is in working condition; that the correct gas valves are closed; and that no gas is leaking into the furnace.
2. Open stack damper and all doors.
3. Start furnace fan.
4. Blow full supply of air through the furnace for 15 min., then turn off air cocks.
5. Apply torch to a burner and turn on a fair amount of gas. Make sure this gas is ignited and then turn on the air cock.
6. Flame at this point should be slightly reducing with streaks of yellow in it.
7. Light a second burner nearby or across the furnace in similar fashion.
8. Put more air on from time to time until flame has bluish case and a good body. Do not make flame a blast. This is not a heating flame and it is easily extinguished.
9. After ten or fifteen minutes, light a few more burners in the furnace as before. If there are a large number of burners on the furnace, light every other one for the first few hours, putting on a moderate amount of gas so the furnace will have a chance to expand normally without damage to brickwork.
10. When the furnace has reached 1000 to 1200 degrees F., the doors should be closed, all the burners turned on, stack damper regulated, and the furnace placed on automatic control.

Case 2—If the furnace is fitted with high pressure inspirating burners, the following procedure should be followed:

1. The same preliminary steps should be taken as described in items 1 and 2 of Case 1.
2. Turn burner air shutter to closed position.
3. Apply open flame under burner nose or under tile.
4. Turn on 1 to 2 lb. of gas pressure. When the burner lights, quickly open the air shutter to give the burner some air but not enough to blow out the flame.
5. In 10 or 15 minutes turn on more gas and a little more air.
6. Particular care should be observed if the furnace is wet so that vapor does not smother the flame. If there is a tendency toward smothering, allow a little more draft, if possible. If this is not possible, cut the gas pressure slightly to reduce the volume of furnace gases.
7. If the furnace is full of intermittent green flame, the gas is not being burned. Cut some gas off and clear up the furnace. Adjust air so the flame starts burning from burner tile. The condition described above is hazardous in a cold furnace.
8. Heat up the furnace in a slightly oxidizing atmosphere. Do not go to extremes. A little red flame out of doors is a healthy sign.
9. When the furnace has reached 1000 to 1200 degrees F. the doors should be closed, all the burners turned on, stack damper regulated, and the furnace placed on automatic control.

Case 3—If the furnace is of the regenerative or recuperative type:

1. The same preliminary steps should be taken as described in items 1, 2, 3, and 4 of Case 1.
2. Provide a live wood fire under the burners.
3. Adjust the air butterfly in the main air duct to the burners to ¼ open or less.
4. Apply a torch to a burner and turn on the gas cock to the burner with a moderate flow of gas. Similarly light more burners in the line until a sufficient number are turned on to heat the furnace.
5. Adjust main air butterfly to make a full-bodied, slightly oxidizing flame.
6. A regenerative furnace should not be reversed until the furnace has sufficient temperature to ignite the gas at the opposite end of the furnace (1000 to 1200 degrees F.). The reverse cycle may be shortened as the furnace heats up but should not be less than 15 minutes during heating-up period.
7. When the furnace has reached 1000 to 1200 degrees F. the doors should be closed, all the burners turned on, stack damper regulated and the furnace placed on automatic control.

No discussion of this nature would be complete without touching on the procedure used to shut down a gas fired furnace. The general procedure is as follows:

1. Shut off the individual gas cock to each burner. If the furnace is equipped with inspirating burners, close air shutter and immediately close gas cock.

2. Shut off main gas cock to the furnace.
3. Shut down fan.
4. Close furnace damper and furnace doors.
5. Open gas bleeder cock on burner header.

In the treatment of safety practices on gas fired furnaces it might be interesting to describe a hypothetical case in which a furnace was being operated while a dangerous condition existed. In other words the furnace was about to explode and we pass by—what to do?

We see this furnace insufficiently hot to consume fuel which is turned on it; a number of the burners are out but blowing in raw gas and air; the furnace flues and stack are full of this mixture which has an alternately green and reddish appearance; the furnace pressure is fluctuating or puffing irregularly. With this setting we are in very great danger. Our procedure during the next few seconds should be as follows:

1. Shut off the gas burners or main gas valve.
2. Warn everyone away from the furnace *quickly*.
3. If the furnace is equipped with a fan, shut it down.
4. Open all furnace doors wide and open stack damper. Use caution. Do not stand in front of a door.
5. Allow furnace to stand for 30 minutes, then light up as previously outlined.

With gas fired installations operating at comparatively low temperatures with little or no supervision, particular precautions should be taken to avoid trouble from slugs of water in the gas. When a slug of water passes through a burner it is extinguished momentarily. If the burner tile is not sufficiently hot, the gas will not ignite again and the furnace will be filled with gas in a few moments, and a serious explosion may result. To protect against this hazard, an electric solenoid shut-off gas valve to be operated from flame failure should be installed in the gas line to the burners. If flame failure occurs, it will be necessary for the operator to shut off the individual valves to the burners, manually reset the solenoid valve, and light each burner again.

On installations where large quantities of gas are used there is usually a pressure regulator to give even pressure at all flows. As a safety measure the specifications for this regulator should read as follows:

"The regulator regulates the pressure in the main gas header by controlling the butterfly valve to maintain this pressure. A secondary impulse is obtained from the upstream side of the butterfly valve. When this upstream pressure drops below a predetermined point, it will cause the butterfly valve to close, regardless of the fact that the pressure below the butterfly valve is less than that required."

With a regulator as described above, the gas system is protected against gas failure. Should the gas pressure fail without such protection of the system as described, there would be immediate danger of open burners back firing into the main header, where a major explosion would result.

There are certain hazards attendant to gas burning which cannot all be covered in this paper. However, we list a few which we feel should be pointed out and guarded against.

1. Lack of knowledge of fuel and equipment.
2. Lack of proper care through:
   a. Haste.
   b. Thoughtlessness.
3. Inappropriate installations as:
   a. Setting unsuitable for job to be done.
4. Improper installations as:
   a. Wrong burner.
   b. Wrong tile.
5. Bad or faulty equipment.
   a. Leaky valves and pipe joints.
   b. Improper bracketing of burners and pipework.
   c. Worn or burnt out tile.
   d. Insufficient light.

To the fuel or combustion man falls the task of installing combustion equipment and teaching operators the proper use of this equipment. This task should be taken in all seriousness because, in addition to doing his job properly, the combustion man is rendering a service to safety.

We list a number of things which we feel the combustion man should "get over" to the operator.

1. Make sure that the operators understand thoroughly the mechanics of the furnace.
   a. Location of stack damper.
   b. Location of stack damper control.
   c. Combustion controls and manual alternates.
   d. Fuel valves on main lines as well as burners.
   e. Air valves and controls.
   f. Door mechanics.
   g. All electric push buttons and their function.
2. Make certain that operators have the proper appreciation of the dangers involved and the responsibility incumbent upon them during each shift they work.
3. Make sure that proper lighting-up equipment is available.
4. Issue full written instructions for light-up, shutdown, and operation of furnace.
5. Follow up closely all details and repeat instructions as often as necessary until thoroughly understood.
6. Enforce important items tactfully but positively.
7. Listen to and encourage suggestions from operators.

It is our opinion that lubricated plug cocks should be used everywhere to shut off gas in preference to either gate or globe valves. If men are to be put to work in a furnace or in intimate contact with the furnace, the main gas line should be blanked off. A spectacle valve should be installed in a suitable spot so this precaution can be taken without loss of time.

PART VI—PRECAUTIONS IN THE BURNING OF PREMIXED GASES

By H. L. HALSTEAD

In a system burning premixed gas, the fuel gas and combustion air are mixed at a central station and piped to the burner.

At the central station, or, using a trade name, "industrial carburetor" air and gas at atmospheric pressures are piped through a proportioning valve, which maintins the correct gas-air ratio, to a turbo-compressor. The turbo-compressor thoroughly mixes the gas and air and boosts the mixture pressure for distribution to the burners.

When maximum heat release per cubic foot of furnace volume is the sole requisite, the gas and air are mixed in the correct proportions for complete combustion. The resulting mixture is highly explosive. Recognizing this fact, that the mixture is explosive, is the first step toward safe operation of a premixed gas system.

With the aim in view of reducing the explosion hazard, the following precautions should be taken when designing and operating such a system.

From the safety point of view a large installation should be composed of a number of small units, each separated one from the other. Long runs of pipe from the carburetors to the burners should be avoided. The mixture lines should be located where there is no danger of the mixture igniting in the pipe line because of local overheating.

Welding, while perfectly safe on ordinary fuel gas mains should never, under any circumstances, be attempted on premixed gas lines.

The turbo-compressor should be constructed so as to eliminate any internal sparking or local overheating of compressor parts.

In order to prevent the compressor from pulling a suction on the fuel gas main during gas failures, a pressure switch should be installed on the gas feeder line. During periods of extremely low fuel gas pressure, the pressure switch opens and shuts down the compressor.

Sufficient softheads should be located at strategic points along the mixture headers. In case of a backfire or an explosion in the mains, these softheads burst and relieve the pressure. Adequate screening must be provided around the softhead to prevent pieces of it from flying through the air when the softhead bursts.

In a premixed system, burner backfires are especially hazardous. Therefore, the burning equipment is specifically designed to eliminate this hazard. Backfiring occurs when the rate of flame propagation is greater than the velocity of the gas-air mixture through the burner head. The rate of flame propagation decreases with the diameter of the tube through which the gas-air mixture is passing. In tubes of extremely small diameter flame propagation is impossible. The premixed gas burner, making use of this principle, consists of a burner head made from a plate drilled with a number of small holes. Each hole is about .040 in. in diameter. Normally these small holes prevent the mixture from backfiring through the burner head.

As an additional safeguard against the burner's backfiring into the main headers, a fire check is placed in the line immediately preceding each burner. The firecheck consists of a spring loaded valve held open against the force of a spring by a light fuse wire. After this valve a series of fine wire screens are placed adjacent to the fuse wire. If the mixture backfires through the burner, the flame is stopped at the screens. The mixture, burning at the screens, melts the fuse wire, allowing the spring loaded valve to close. The valve shuts off the flow of gas-air mixture to the burner.

In addition to the fire checks, a backfire preventer is placed between the carburetor and main supply line to the burners. Except for size, the backfire preventer is similar to the firechecks. It contains a number of small screen inserts acting as firechecks which, together with a fuse wire and a spring loaded valve serve the same purpose as the similar parts in the smaller firechecks. In addition a softhead is incorporated in the backfire preventer. If an explosion occurs the softhead releases the fuse wire, allowing the spring loaded valve to close. The valve stops the flow of gas-air mixture from the carburetor to the main burner supply line.

The operation of a premixed gas system should be placed in the hands of men who have been specifically instructed in the operation and maintenance of the equipment. They should be familiar with the manufacturer's instructions and should follow a definite routine in starting up and shutting down the system.

It is absolutely necessary that the operators keep the equipment clean and in good operating condition at all times so that it functions well in emergencies.

In general, the same precautions should be used in lighting a premixed gas burner as are used in lighting an ordinary gas burner. Before starting the compressor, make certain that all burner valves are closed. The lighter torch should be inserted over the burner before the gas valve is opened. Except in cases of emergency, all burner valves should be closed before the compressor is shut down.

Briefly, three things are important to remember in burning premixed gas: One, that an explosive mixture of gas and air is being handled; two, that the burning equipment should be designed to prevent backfires; and three, that the operators should be thoroughly instructed in the safe operating of the system.

PART VII—SAFETY PROCEDURE IN HEAVY OIL FIRED FURNACES

By E. C. DAVIS

In general, it may be stated that there are fewer dangers encountered in the operation of oil fired furnaces than with gas fired furnaces; the main difference between the two being that gas is already in a condition for instantaneous ignition, whereas oil must be vaporized before ignition can take place.

Fuel oils are usually classified into six grades, on a basis of viscosity and distillation temperature. Since the low viscosity oils are generally used on small heating burners which invariably have sufficient safety features incorporated in their design I will limit my remarks to the application of the heavier oils commonly employed in industrial heating. These oils have a minimum flash point of 150 degrees F. and always require preheating for satisfactory combustion.

In regard to the design of an oil fired furnace, it should be pointed out that there should be ample space for combustion of the required amount of fuel, without restrictions that would tend to create a pulsating flame, and that there should be sufficient flue space to carry away the burned gases without creating excessive back pressure.

The greatest hazard encountered in the operation of oil fired furnaces is the improper selection and maintenance of burners and auxiliary equipment. It is important that oil piping and metallic hoses must be free from leaks, that hoses must be able to withstand considerable rough handling, and that burners must be able to provide good atomization of oil over a wide range of firing rates. The burner tile serves the function of heating the air-oil mixture to ignition temperature,

and must be properly proportioned so that it will provide this heat without collecting oil to such an extent that large quantities of carbon are deposited on its surface.

The burner controls must be so proportioned that it is impossible to pass any great excess of oil in relation to the quantity of air furnished for combustion. In this connection it is important that the operator makes sure that the burner tip is complete before attempting to turn on an oil burner. If these precautions are ignored, a large quantity of oil can accumulate inside the furnace in a very short time, and under certain conditions it is possible for the entire mass of fuel to ignite at once, causing an explosion, the intensity of which cannot be predicted. Along with such an explosion, even if it does not damage the furnace, there is usually sufficient backfire to burn the operator if he is within a few feet of the burner port.

In the case of a water cooled burner, the burner must have a reliable steady supply of clean water so that there will be no danger of the burner melting away and leaving an open oil pipe to discharge into the furnace.

The temperatures within open oil heating tanks must be so controlled that it is impossible for the oil to be heated above any temperature at which large quantities of vapor are given off. This is usually in the neighborhood of 175 degrees F.

While combustion controls are designed to maintain a constant ratio of oil to air, if these are not given proper attention, it is possible that they may not cut back the oil flow to the same extent as the air flow. In the case of a blast type burner, oil will then dribble from the burner, leaving a fire hazard outside the furnace.

Procedures to be followed in lighting an oil fired furnace are as follows:

1. Open flue damper and sufficient furnace doors to give free vent to any explosion that may occur while lighting the burner.
2. Start furnace fan, and allow air to circulate in the furnace for a few minutes.
3. Make sure that all burner parts are in place, and that hoses, unions, etc., are tightly connected.
4. Examine the furnace for oil or oil fumes, and if found, remove same before lighting the furnace.
5. Make sure that all burners on the furnace are turned off before attempting to light any one of them.
6. Use a torch or wad of oily waste large enough to provide a steady flame for several minutes.
7. Always turn on air supply to the individual burner before turning on the oil, and follow the reverse order in shutting off a burner.
8. If it becomes necessary to adjust the position of a burner, turn off oil before making such adjustment. This precaution will prevent what might otherwise be a serious burn if the burner should slip away from the burner port and splatter against the side of the furnace.
9. When lighting a cold furnace, make sure that the burner is burning with a steady flame before leaving the furnace. Usually the first five to ten minutes will determine whether the burner will stay lighted.
10. When using kerosene for cleaning burners, keep it at a safe distance from the burner port. Do not use gasoline for cleaning, unless the parts are taken to a cool, exposed place.
11. If a yellow or white fume begins to appear when lighting a cold furnace, shut off oil immediately, and keep open lights away from the furnace until the atmosphere clears. These fumes are really nothing more than oil fog, and indicate that there is not sufficient heat furnished by the pilot light to sustain combustion, or that the proportion of air to oil is outside the explosive range.
12. The person lighting the furnace should have a light-up kit consisting of kerosene, oil-soaked waste, a wire fork for holding the waste, and matches. Never try to light an oil burner with a poorly burning torch.

Unless it is known that an operator will always be near the furnace, the furnace controls should include a safety shut-off valve arranged to operate either due to flame failure, or failure of the air supply. This will prevent large accumulations of oil inside the furnace, which would constitute a hazard when the furnace is relighted.

The furnace should have at least one cubic foot of volume for every 33,000 Btu. of fuel burned per hr. If the furnace volume is too small, the oil flame will not burn; will either puff badly or go out altogether.

DISCUSSION

PRESENTED BY

M. J. CONWAY, *Special Engineer,* Lukens Steel Company, Coatesville, Pennsylvania.

L. J. GOULD, *Assistant Chief Engineer of Construction,* Bethlehem Steel Company, Bethlehem, Pennsylvania.

N. C. BYE, *Chief Engineer,* Henry Disston and Sons, Inc., Philadelphia, Pennsylvania.

J. S. MORRIS, *Combustion Engineer,* Bethlehem Steel Company, Sparrows Point, Maryland.

A. J. FISHER, *Fuel Engineer,* Bethlehem Steel Company, Sparrows Point, Maryland.

L. F. COFFIN, *Superintendent of Mechanical Department,* Bethlehem Steel Company, Sparrows Point, Maryland.

M. J. CONWAY: I have enjoyed this paper very much, and submit that the best type of safety device is a well informed furnace operator. The training of these operators should be part of the function of the fuel engineering department.

In the practice of fuel economy, it is often necessary to employ the services of various kinds of gadgets such as dash pots, diaphragms, knife edges, metal contacts, etc., which, in the aggregate, add up to complicated mechanisms which require well-planned inspections and service work. Safety devices should be as simple in design as it is possible to make them and be reliable.

I would like to ask one question which is related to the subject of this paper. What means of detection is

used to find the location of underground gas leaks? I am at present using the ether method and wondered if a better method could be suggested.

L. J. GOULD: I was interested in that part of the paper about the carbon monoxide and the headaches attached to it—I can assure you that is true. We did a job one time that had enough headaches attached to it, without having to worry about carbon monoxide. The idea was to get inside of the 1000-ton furnace and remove the bricks without taking the stock out of the furnace, so we were getting on top of a gas producer to work, and one of the things that made it possible was a carbon monoxide detector that took continual samples. The idea was to put the detector down to detect the gases and lower a scaffold to replace the brick, but because of the detector the headaches were all in advance, when we were figuring out how to do it. Several times during the course of the job the operator stationed at the gas indicator called our attention to the condition, which was then quickly corrected. But that was the most interesting illustration of the use of that equipment we ever ran into.

N. C. BYE: Did I understand you to say that the material in this paper was prepared and put into book form for the use of plant employes?

J. S. MORRIS: These papers, which will be distributed in typewritten form, probably not in book form, will be available for all departments, for use of their safety meetings that they hold regularly.

A. J. FISHER: In answer to Mr. Bye's question as to the education of the operators at the plants, melters, heaters, etc., we abridge all our set-ups of safety codes and go directly to the operator and specifically instruct him ourselves—and we feel that is part of our job. In addition, we give the foremen a thorough working knowledge of the safety angle. This way everyone gets it first hand.

In the matter of safety regulators in a plant where we are particularly desirous of maintaining safe conditions, we not only have one safety regulator, but in some instances we will have three in series so in case one failed, the other two would operate, or in the case that two failed the other one would operate. I think it is important to have a first, second and third defense in practically all installations.

In starting up a new installation, we stay with the operator, trying to teach him all we know, and as we leave him there for the night run or whatever the case may be, I always say to him, "Watch it carefully, and in case it blows up you will be docked for the time you are up in the air"—and that sort of brings him around—he really believes he has to watch himself and that if he doesn't watch, something might happen to him. It starts him to thinking.

L. F. COFFIN: One comment I would like to make regarding a point that was touched on lightly is the importance, in cases of shutdown and the necessity of getting inside of gas lines or furnaces fed with gas, of not relying on any valve after it has once been shut off to prevent the gas leaking into the furnace, even though the job has been purged.

As far as I know, there are only two reasonably safe methods of preventing leakage after shutdown: One is a blank between two flanges; and the other is an adequate water seal with water running. We are particular in all installations to provide a means of proper blank shut-off between the valve and the furnace, and require all maintenance men to be sure that blank is in place before doing any work on the furnace. Many bad explosions have resulted in different parts of the country because of failure to observe that practice.

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D-C. MILL MOTOR STANDARDS

REPORT OF THE COMMITTEE ON REVISION OF A. I. S. E. STANDARDIZED D-C. MILL MOTOR

By G. R. CARROLL, *Chairman*

▲ THE Preliminary Report of the Standardization Committee of the A.I.S.(E.)E. on the Standardized Commutating Mill Type Motor is recorded on pages 262–272 of the 1926 Year Book and the final report including the final outline dimensions is given on pages 247–249 of the 1928–29 Year Book.

When this original standardization was being developed, a questionnaire was sent to the active members of the Association to obtain their opinion concerning several important items. One of the questions was: "Do steel mill engineers desire mill type motors designed to accommodate anti-friction bearings only rather than motors designed to permit the installation of either anti-friction or sleeve bearings?" The answer to this was 60 per cent "No" and 40 per cent "Yes." It was therefore considered advisable to standardize on a design with bearing space sufficient to accommodate either type of bearing. The result was a design which was afterwards designated as the long frame motor.

A short time later one manufacturer developed a line of frames with bearing space of the end housings sufficient only for anti-friction bearings. This permitted shorter overall length of motor which was very desirable for certain applications. This line was designated as the short frame motor.

During the ten years since the standard mill type motor was established a number of items have been considered by the motor manufacturers such as additional ratings, speeds of shunt and compound motors, supplementary ratings, etc. The chairman of the Standardization Committee of the Association, F. D. Egan, recommended to the Board of Directors that further standardization work be considered to bring the subject of standardization up to date and at a meeting held June 12, 1939, the Board authorized the formation of a committee for this purpose. G. R. Carroll was appointed chairman and his committee included the following active members: I. N. Tull, James Farrington, and Wray Dudley, and representatives of three electrical companies, namely: F. B. Hynes and J. R. Lewis, Crocker Wheeler Electric Manufacturing Company, C. B. Hathaway and G. A. Caldwell, Westinghouse Electric and Manufacturing Company, C. W. Lange and T. R. Rhea of the General Electric Company.

The findings of the committee are as follows:

1. The standard d-c. mill motor of the future is to be the short frame motor, and the long frame motor is to be considered as a modification of the standard motor. A review of the orders for the two types indicates that the present demand is for the short frame motor in the majority of cases, and that this demand is steadily increasing.

2. The basic 1 hr. 75 degrees C. totally enclosed ratings of the standard line are as follows: 5 hp., 7½ hp., 10 hp., 15 hp., 25 hp., 35 hp., 50 hp., 75 hp., 100 hp., and 150 hp. The ratings which were added to the original line are 5 hp., 100 hp., and 150 hp., and only the short frames were developed.

3. Outline dimensions of the standard line of short frame motors are shown in Figure 1. Included are such details as a section through the pinion on the armature shaft extension with pertinent dimensions, and minimum diameters of counter-bores in couplings to provide clearance for wrenches used on the armature shaft nuts of all makes of motors.

4. Standard hp. and speed ratings of totally enclosed and protected self-ventilated, 230 volts and 550 volts, series, compound and shunt wound motors for various time ratings are shown in Figure 2. Hp. and speed ratings for 230 volt, adjustable speed, shunt or stabilized shunt wound, totally enclosed motors are also shown. In addition, normal torque ratings, values of maximum starting torque, and maximum running torque for all frame sizes are shown.

ENCLOSED DIRECT CURRENT MILL MOTORS

SERIES, COMPOUND, AND SHUNT WOUND

MOTOR FRAME				1/4 HOUR, 75°C. RISE				1/2 HOUR, 75°C. RISE				1 HOUR, 75°C. RISE				5 HOURS CONTINUOUS, 75°C. RISE				5 HOURS RMS, 75°C. RISE 50% TIME ON DUTY CYCLE				TORQUE IN POUNDS AT 1 FOOT RADIUS									
					RPM				RPM				RPM				RPM				RPM			1 HOUR, 75°C. RISE			MAX. STARTING *			MAX. RUNNING #		
AISE	GE	W	C-W	HP	SERIES	COM-POUND	SHUNT	HP	SERIES	COM-POUND	SHUNT	HP	SERIES	COM-POUND	SHUNT	HP	SERIES	COM-POUND	SHUNT	HP	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT
230 VOLTS																																
2	MD-402	MC-21	SW-5	7 1/2	610	840	960	6 1/2	750	925	980	5	900	1025	1025	3 1/2	1080	1200	1100	4	1020	1140	1075	29	25.5	25.5	145	115	92	116	90	75
3	MD-403	MC-31	SW-7 1/2	11 1/2	560	710	850	10	650	775	875	7 1/2	800	900	900	4 1/2	1050	1085	965	5 1/2	950	1025	950	49	44	44	245	198	158	196	154	130
4	MD-404	MC-41	SW-10	17	515	635	750	13 1/2	610	700	775	10	725	800	800	6	950	925	840	7	875	885	825	72	65.5	65.5	360	295	235	288	230	195
6	MD-406	MC-61	SW-15	23 1/2	475	615	685	19	560	650	700	15	650	725	725	7 1/2	1025	885	770	9 1/2	860	830	750	121	109	109	605	490	390	484	382	325
8	MD-408	MC-81	SW-25	45	420	530	620	33	500	625	635	25	575	650	650	13	800	785	685	17	680	730	675	228	202	202	1140	910	730	912	710	600
10	MD-410	MC-101	SW-35	63	385	460	540	45	460	525	560	35	525	575	575	18	740	675	600	22	670	650	590	350	320	320	1750	1440	1150	1400	1120	960
12	MD-412	MC-121	SW-50	90	385	435	500	65	440	500	535	50	500	550	550	22 1/2	720	640	565	31 1/2	620	600	560	525	477	477	2625	2150	1720	2100	1670	1430
14	MD-414	MC-141	SW-75	135	360	410	485	100	420	475	500	75	475	515	515	37	700	600	525	42	615	580	520	830	765	765	4150	3440	2750	3320	2700	2290
16	MD-416	MC-161	SW-100	180	350	400	450	135	410	440	470	100	460	485	485	46	685	550	505	55	590	535	500	1140	1080	1080	5700	4860	3890	4560	3780	3240
18	MD-418	MC-181	SW-150	275	350	390	440	200	400	430	450	150	450	460	460	66	675	520	480	100	515	500	475	1750	1710	1710	8750	7700	6150	7000	6000	5130
550 VOLTS																																
2	MD-402	MC-21	SW-5	7 1/2	765	985	1075	6 1/2	840	1040	1100	5	1015	1150	1150	3 1/2	1270	1300	1200	4	1200	1240	1175	26	23	23	105	85	70	90	65	60
3	MD-403	MC-31	SW-7 1/2	11 1/2	675	870	985	10	765	925	1000	7 1/2	935	1025	1025	4 1/2	1185	1210	1050	5 1/2	1075	1150	1040	42	38	38	170	135	115	145	105	95
4	MD-404	MC-41	SW-10	17	610	760	850	13 1/2	700	810	865	10	810	885	885	6	1115	1025	920	7	1035	1000	910	65	59	59	260	210	175	230	165	150
6	MD-406	MC-61	SW-15	23 1/2	550	700	750	19	625	750	775	15	725	800	800	7 1/2	1060	1000	850	9 1/2	950	925	840	109	98	98	435	350	295	380	275	245
8	MD-408	MC-81	SW-25	45	475	575	675	33	570	675	685	25	635	700	700	13	925	850	725	17	800	800	720	207	188	188	830	675	565	725	525	470
10	MD-410	MC-101	SW-35	63	415	550	585	45	515	600	610	35	585	625	625	18	850	725	650	22	750	700	645	314	294	294	1255	1060	880	1100	825	735
12	MD-412	MC-121	SW-50	90	400	500	560	65	470	560	575	50	530	585	585	22 1/2	750	700	600	31 1/2	650	650	590	495	449	449	1980	1615	1345	1735	1255	1125
14	MD-414	MC-141	SW-75	135	385	450	525	100	450	500	540	75	510	550	550	37	740	635	570	42	685	615	565	772	716	716	3090	2580	2150	2700	2000	1790
16	MD-416	MC-161	SW-100	180	375	425	460	135	425	460	480	100	475	500	500	46	710	575	525	55	625	550	520	1105	1050	1050	4420	3780	3150	3870	2940	2625
18	MD-418	MC-181	SW-150	275	365	410	440	200	410	435	450	150	460	460	460	66	675	540	480	100	550	500	475	1710	1710	1710	6850	6170	5135	6000	4800	4280

PROTECTED SELF-VENTILATED DIRECT CURRENT MILL MOTORS

SERIES, COMPOUND, AND SHUNT WOUND

MOTOR FRAME				1 HOUR, 75°C. RISE				CONTINUOUS, 75°C. RISE				TORQUE IN POUNDS AT 1 FOOT RADIUS											
					RPM				RPM			CONTINUOUS, 75°C.			MAX. STARTING *			MAX. RUNNING #		
AISE	GE	W	C-W	HP	SERIES	COM-POUND	SHUNT	HP	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT	SERIES	COM-POUND	SHUNT
230 VOLTS																				
3	MDP-403	MCP-31	SW-7 1/2	8	740	885	890	7	800	940	910	46	39	40	245	198	158	196	154	130
4	MDP-404	MCP-41	SW-10	12	650	735	785	9 1/2	750	825	800	66	60	62	360	295	235	288	230	195
6	MDP-406	MCP-61	SW-15	16 1/2	615	700	715	13	700	765	730	97	89	93	605	490	390	484	382	325
8	MDP-408	MCP-81	SW-25	30	515	630	640	23	600	700	660	202	173	183	1140	910	730	912	710	600
10	MDP-410	MCP-101	SW-35	40	495	550	565	30	575	610	580	274	258	272	1750	1440	1150	1400	1120	960
12	MDP-412	MCP-121	SW-50	57 1/2	470	525	540	40	550	585	550	382	359	382	2625	2150	1720	2100	1670	1430
14	MDP-414	MCP-141	SW-75	90	435	490	500	60	525	550	515	600	573	612	4150	3440	2750	3320	2700	2290
16	MDP-416	MCP-161	SW-100	135	410	440	470	100	460	485	485	1140	1080	1080	5700	4860	3890	4560	3780	3240
18	MDP-418	MCP-181	SW-150	200	400	430	450	150	450	460	460	1750	1710	1710	8750	7700	6150	7000	6000	5130
550 VOLTS																				
3	MDP-403	MCP-31	SW-7 1/2	8	850	1000	1020	7	950	1050	1035	39	35	36	170	135	115	145	105	95
4	MDP-404	MCP-41	SW-10	12	750	840	875	9 1/2	850	900	885	59	55	56	260	210	175	230	165	150
6	MDP-406	MCP-61	SW-15	16 1/2	700	780	785	13	800	850	820	85	80	83	435	350	295	380	275	245
8	MDP-408	MCP-81	SW-25	30	600	680	690	23	690	750	710	175	161	170	830	675	565	725	525	470
10	MDP-410	MCP-101	SW-35	40	550	610	615	30	625	650	635	252	243	248	1255	1060	880	1100	825	735
12	MDP-412	MCP-121	SW-50	57 1/2	500	570	575	40	580	620	585	362	339	359	1980	1615	1345	1735	1255	1125
14	MDP-414	MCP-141	SW-75	90	475	530	545	60	565	575	560	558	548	562	3090	2580	2150	2700	2000	1790
16	MDP-416	MCP-161	SW-100	135	425	460	480	100	475	500	500	1105	1050	1050	4420	3780	3150	3870	2940	2625
18	MDP-418	MCP-181	SW-150	200	410	435	450	150	460	460	460	1710	1710	1710	6850	6170	5135	6000	4800	4280

ENCLOSED DIRECT CURRENT ADJUSTABLE SPEED MILL MOTORS

SHUNT OR STABILIZED SHUNT WOUND

MOTOR FRAME				1 HOUR, 75°C. RISE	
AISE	GE	W	C-W	HP	RPM
230 VOLTS					
2	MD-402	MC-21	SW-5	5	1025/2050
3	MD-403	MC-31	SW-7 1/2	7 1/2	900/1800
4	MD-404	MC-41	SW-10	10	800/2000
6	MD-406	MC-61	SW-15	15	725/1800
8	MD-408	MC-81	SW-25	25	650/1950
10	MD-410	MC-101	SW-35	35	575/1725
12	MD-412	MC-121	SW-50	50	550/1650
14	MD-414	MC-141	SW-75	75	515/1300
16	MD-416	MC-161	SW-100	100	485/1200
18	MD-418	MC-181	SW-150	150	460/1150

ENCLOSED FORCED VENTILATED DIRECT CURRENT MILL MOTORS

SERIES, COMPOUND, AND SHUNT WOUND

230 & 550 VOLTS

THE CONTINUOUS, 75°C. RISE RATINGS OF ENCLOSED FORCED VENTILATED MOTORS ARE EQUAL TO THE 1 HOUR, 75°C. RISE TOTALLY ENCLOSED RATINGS WHEN THE REQUIRED VOLUME OF VENTILATING AIR IS SUPPLIED TO THE MOTORS.

* THE VALUES FOR MAXIMUM STARTING TORQUE ARE BASED ON THE FOLLOWING APPROXIMATE RATIOS TO THE CORRESPONDING 1 HOUR TOTALLY ENCLOSED TORQUE RATINGS:

APPROX. RATIO MAX. STARTING TORQUE TO 1 HOUR ENCLOSED TORQUE

VOLTS	SERIES	COMPOUND	SHUNT
230	5	4.5	3.6
550	4	3.6	3

THE VALUES FOR MAXIMUM RUNNING TORQUE ARE BASED ON THE FOLLOWING APPROXIMATE RATIOS TO THE CORRESPONDING 1 HOUR TOTALLY ENCLOSED TORQUE RATINGS:

APPROX. RATIO MAX. RUNNING TORQUE TO 1 HOUR ENCLOSED TORQUE

VOLTS	SERIES	COMPOUND	SHUNT
230	4	3.5	3
550	3.5	2.8	2.5

A. I. S. E. Standardized Direct Current Mill Motor Ratings

NOTES:-

MILL RATINGS (BASIC RATING) 1 HOUR, 75 C. ENCLOSED

CRANE RATING 1/2 HOUR, 75 C. ENCLOSED

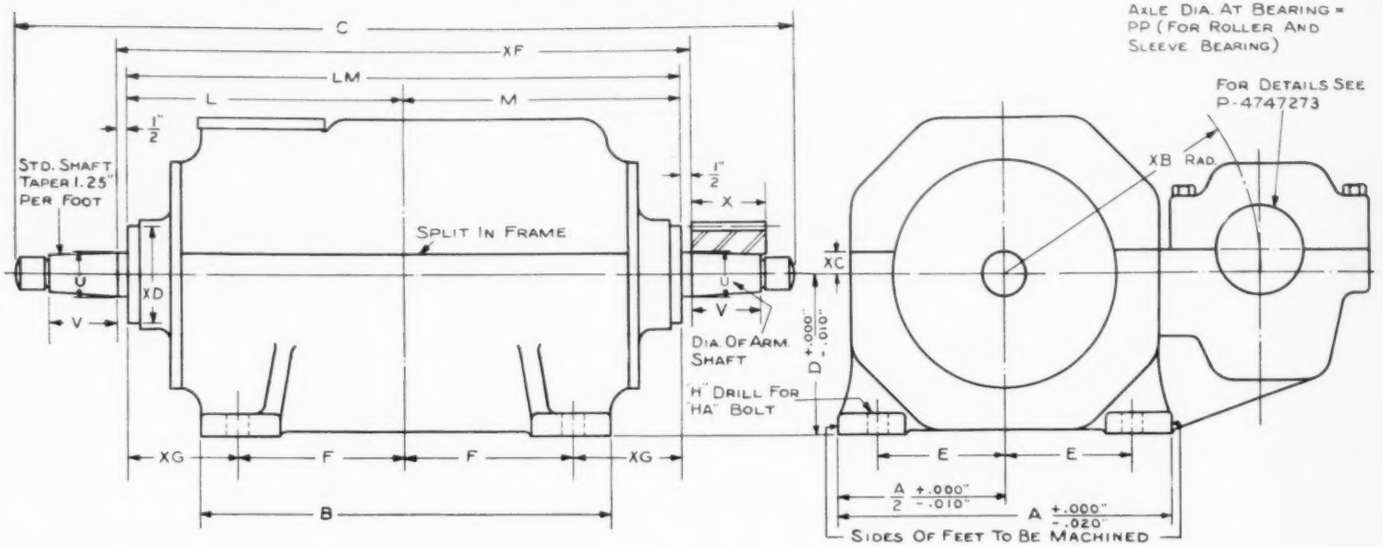
△ LIMITING DIMENSION

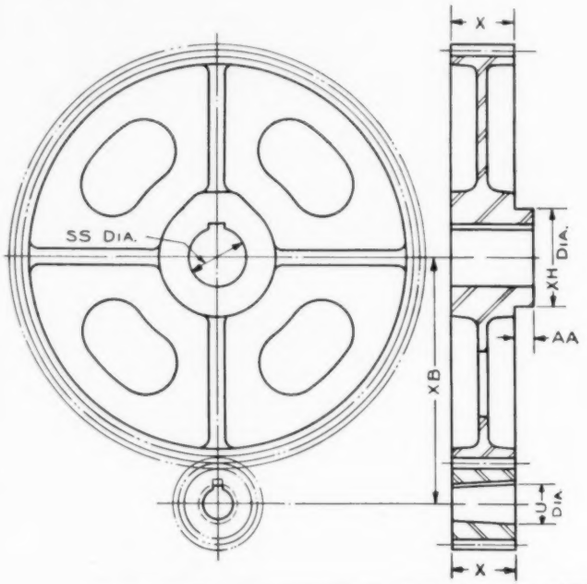
KEYWAY TO BE CUT PARALLEL TO TAPER-CUTTER TO BE RUN OUT.

* 300 SERIES ROLLER BEARINGS OF SAE STANDARD DOUBLE WIDTH. IF SHORTER BEARINGS ARE USED SUITABLE SPACER IS TO BE USED SO THAT THE WIDTH OF INNER RACE PLUS SPACER IS EQUIVALENT TO SAE WIDTH.

ϕ 230 VOLTS, SERIES WOUND

+ COUNTERBORE IN COUPLING, IF USED, TO PROVIDE WRENCH CLEARANCE.





MOTOR FRAME				RATING & SPEED ϕ				TORQUE ϕ LB.FT.		GEAR RATIO	A	AA	B	C	D	E	F	H	HA
				MILL		CRANE													
AISE	GE	W	C-W	HP	RPM	HP	RPM	MILL	CRANE	STD.									
2	MD-402	MC-21	SW-5	5	900	6 1/2	750	29	46	5.07	15	7/8	19	32 7/8	7 5/8	6 1/4	8 1/4	25/32	3/4
3	MD-403	MC-31	SW-7 1/2	7 1/2	800	10	650	49	81	4.94	17	7/8	21	37	8 1/2	7	9	29/32	7/8
4	MD-404	MC-41	SW-10	10	725	13 1/2	610	72	116	4.94	18	1	22	39	9	7 1/2	9 1/2	29/32	7/8
6	MD-406	MC-61	SW-15	15	650	19	560	121	178	4.95	20	1	24 1/2	42 1/4	10	8 1/4	10 1/2	1 1/32	1
8	MD-408	MC-81	SW-25	25	575	33	500	228	346	4.94	22 3/4	1 1/8	28 1/2	47 1/2	11 1/4	9 3/8	12 3/8	1 3/16	1 1/8
10	MD-410	MC-101	SW-35	35	525	45	460	350	513	4.94	24 1/2	1 1/8	30 1/2	50 1/4	12 1/4	10 1/4	13	1 3/16	1 1/8
12	MD-412	MC-121	SW-50	50	500	65	440	525	776	5.05	27	1 1/4	33	55	13 3/8	11 1/4	14 1/4	1 5/16	1 1/4
14	MD-414	MC-141	SW-75	75	475	100	420	830	1250	5.05	30	1 1/4	37 1/2	60 3/4	14 3/4	12 1/2	16	1 9/16	1 1/2
16	MD-416	MC-161	SW-100	100	460	135	410	1140	1730	5.05	32 1/2	1 3/8	41	67 1/2	16	13 1/2	17 1/2	1 9/16	1 1/2
18	MD-418	MC-181	SW-150	150	450	200	400	1750	2625	4.94	36	1 7/16	45 1/2	70 5/8	17 3/4	15	19 1/2	1 13/16	1 3/4

MOTOR FRAME				L	M	LM	+.0000 -.0005 PP	SS	U	V	WD +	XB	XC	XD	XF	XG	XH	ARMATURE SHAFT KEY		AXLE SHAFT KEY		ANTI-FRICTION BEARING NUMBER *	STANDARD GEAR RATIO			GEAR CASE △
																		WIDTH	HEIGHT	WIDTH	HEIGHT		PINION TEETH	GEAR TEETH	PITCH	X = FACE	BELOW BASE
AISE	GE	W	C-W																								
2	MD-402	MC-21	SW-5	12	12	24	2.7570	2 5/8	1 3/4	2 3/4	2 3/4	11.375	7/8	4 1/2	25	3 3/4	4 1/2	1/2	1/2	3/4	1/2	309	15	76	4	3	2 1/2
3	MD-403	MC-31	SW-7 1/2	13 1/2	13 1/2	27	3.1507	3 1/8	2	3 1/4	3 1/2	12.625	1	5 1/2	28	4 1/2	5	1/2	1/2	3/4	1/2	311	17	84	4	3 1/2	2 1/2
4	MD-404	MC-41	SW-10	14 1/2	14 1/2	29	3.5445	3 1/2	2	3 1/4	3 1/2	13.375	1	5 1/2	30	5	5 1/2	1/2	1/2	3/4	1/2	311	18	89	4	3 1/2	2 3/4
6	MD-406	MC-61	SW-15	15 1/2	15 1/2	31	3.9383	3 7/8	2 1/2	3 3/4	3 7/8	14.875	1 1/8	6 1/4	32	5	6	1/2	1/2	1	3/4	313	20	99	4	4	2 3/4
8	MD-408	MC-81	SW-25	17 1/2	17 1/2	35	4.3320	4 5/16	3	4 1/4	4 3/4	16.833	1 1/8	7 1/4	36	5 1/8	6 1/2	3/4	1/2	1	3/4	316	17	84	3	4 1/2	3 1/4
10	MD-410	MC-101	SW-35	18 3/4	18 3/4	37 1/2	4.7260	4 11/16	3 1/4	4 1/4	5 1/4	17.833	1 1/8	8	38 1/2	5 3/4	7	3/4	1/2	1	3/4	317	18	89	3	4 1/2	3
12	MD-412	MC-121	SW-50	20 1/2	20 1/2	41	5.1197	5 1/16	3 5/8	4 3/4	5 5/8	19.166	1 1/4	8 3/4	42	6 1/4	8	3/4	1/2	1 1/4	7/8	319	19	96	3	5	3
14	MD-414	MC-141	SW-75	23 1/4	23 1/4	46 1/2	5.9072	5 7/8	4 1/4	4 3/4	6 1/2	21.800	1 1/4	10	47 1/2	7 1/4	9	1	3/4	1 1/2	1	322	18	91	2 1/2	5	4 1/4
16	MD-416	MC-161	SW-100	26	26	52	6.6950	6 9/16	4 5/8	5 1/4	7	24.200	1 1/2	10	53	8 1/2	10	1 1/4	3/4	1 1/2	1	324	20	101	2 1/2	5 1/2	4 1/2
18	MD-418	MC-181	SW-150	27 1/2	27 1/2	55	7.4822	7 3/8	5	5 3/4	7	26.750	1 1/2	10	56	8	11	1 1/4	1 1/4	1 1/2	1	326	18	89	2	6	5

A. I. S. E. Standardized Short Mill Motor Dimensions

5. A.I.S.E. frame numbers for short frame motors were adopted as a convenient and positive means of identifying a particular size when considering the various makes of motors. These A.I.S.E. frame numbers and the corresponding frame designations for three makes of motors are shown in parallel columns in Figures 1, 2, and 3.

6. The bearing housings for armature shaft bearings are designed to accommodate 300 series S.A.E. double width anti-friction bearings. If bearings narrower than these are used, spacers are to be used for the inner races, or the inner races lengthened to suit in the case of self-contained bearings. Suitable spacers for the outer races are also provided if the type of bearing used requires them.

7. Details of the back axle bearing construction are shown in Figure 3. This construction is such as to permit of the interchangeable use of sleeve bearings and anti-friction bearings (in cartridges) without any change in the back axle or the housings. The back axle details of the 150 hp. A.I.S.E. frame 18 motor is being changed by the motor manufacturers to correspond with this standard construction.

8. The sides of the motor feet, parallel to the shaft, are machined to the tolerances shown in Figure 1. A standard tolerance is also shown for the height from the bottom of the motor feet to the centerline of the armature shaft.

A check was made to insure the use of common dimensions of all details which might effect interchangeability of the three lines of motors.

A. I. S. E. Standardized Short Mill Motor Back Axle Details

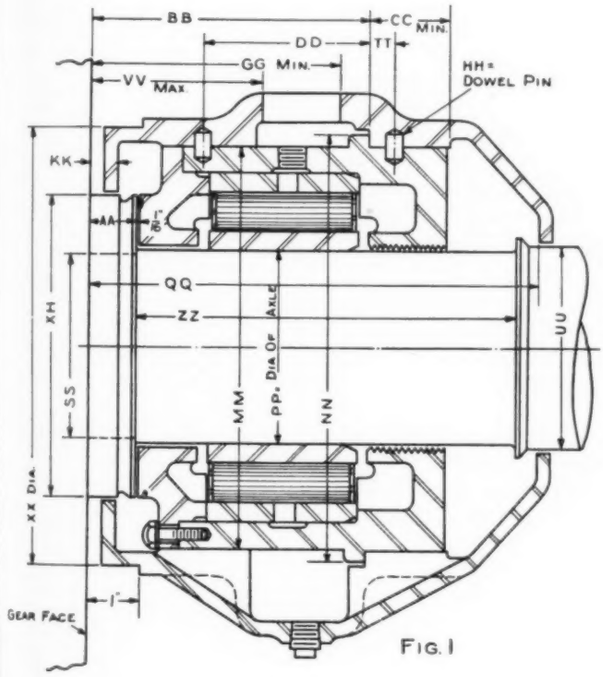


FIG. 1

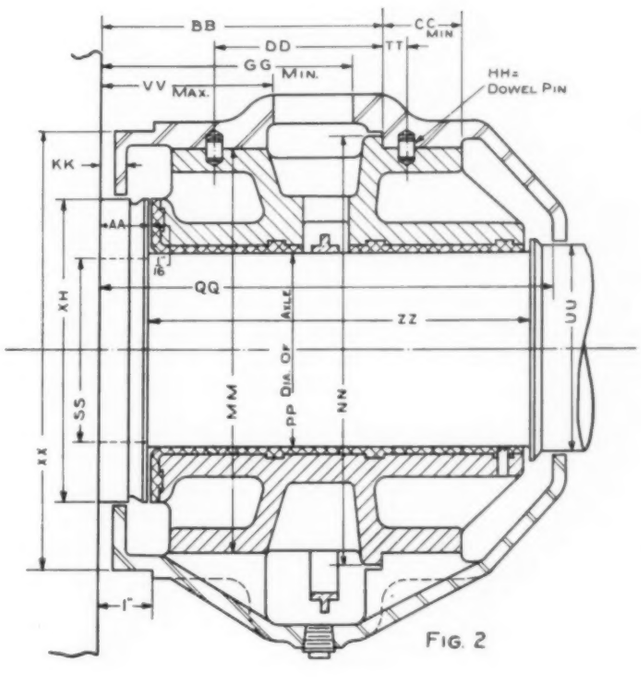


FIG. 2

MOTOR FRAME				FIG.	AA	BB	CC	DD	GG	HH	KK *	MM ‡	NN	+.0000 −.0005 PP	+ QQ	SS	TT	MAXIMUM UU	VV	XH	XX	ZZ #	200 SERIES BEARINGS
AISE	GE	W	C-W	NO.																			
2	MD-402	MC-21	SW-5	1-2	7/8	4 5/8	1 1/8	2 1/2	4 3/8	3/8	1/2	5.937	6 7/16	2.7570	7 1/4	2 5/8	1/2	2 13/16	2 7/8	4 1/2	7 1/8	5 3/4	W-214H
3	MD-403	MC-31	SW-7 1/2	1-2	7/8	5	1 3/8	2 7/8	4 1/2	3/8	1/2	6.500	7	3.1507	7 3/4	3 1/8	1/2	3 3/16	3	5	7 3/4	6 1/2	W-216H
4	MD-404	MC-41	SW-10	1-2	1	5 3/8	1 1/2	3 1/8	4 7/8	3/8	1/2	7.312	7 3/4	3.5445	8 1/2	3 1/2	1/2	3 9/16	3 3/8	5 1/2	8 1/2	7 1/4	W-218H
6	MD-406	MC-61	SW-15	1-2	1	5 7/8	1 3/4	3 1/2	5 1/8	3/8	1/2	8.125	8 5/8	3.9383	9 1/4	3 7/8	1/2	4	3 5/8	6	9 1/2	8	W-220H
8	MD-408	MC-81	SW-25	1-2	1 1/8	6 3/8	2	3 7/8	5 1/2	1/2	9/16	9.125	9 5/8	4.3320	10 1/4	4 5/16	5/8	4 3/8	4	6 1/2	10 1/2	8 3/4	W-222H
10	MD-410	MC-101	SW-35	1-2	1 1/8	6 7/8	2	4 1/2	5 7/8	1/2	9/16	9.750	10 1/4	4.7260	10 7/8	4 11/16	5/8	4 13/16	4 3/8	7	11 1/4	9 1/2	W-224H
12	MD-412	MC-121	SW-50	1-2	1 1/4	7 1/2	2 1/4	4 7/8	6 1/4	1/2	9/16	10.375	10 7/8	5.1197	11 7/8	5 1/16	3/4	5 1/8	4 3/4	8	11 7/8	10 1/4	W-226H
14	MD-414	MC-141	SW-75	1-2	1 1/4	8 1/2	2 1/2	5 3/4	7	1/2	9/16	12.000	12 5/8	5.9072	13 7/8	5 7/8	3/4	6	5 1/2	9	13 1/2	12 1/4	W-230H
16	MD-416	MC-161	SW-100	1-2	1 3/8	9 3/8	2 3/4	6	8 5/8	5/8	5/8	13.625	14 3/8	6.6950	15 1/4	6 9/16	1 1/4	6 3/4	6 1/8	10	15 1/2	13 1/2	W-234H
18	MD-418	MC-181	SW-150	1-2	1 7/16	10 1/2	3	6 1/4	9 1/8	5/8	11/16	14.750	15 1/2	7.4822	17 1/4	7 3/8	1 1/2	7 9/16	6 5/8	11	16 1/2	15 1/8	W-238H

+ QQ=MINIMUM DIMENSION (APPROX.)
‡ MM=FOR SLEEVE AND ROLLER BEARINGS
* KK=MAXIMUM DIMENSION (APPROX.)
# ZZ=IF OIL SLINGER IS USED

WATER TREATMENT *for High Pressure Boilers*

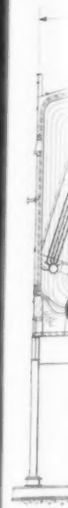
By C. N. ARNOLD

Steam Engineer

YOUNGSTOWN SHEET AND TUBE COMPANY

INDIANA HARBOR, INDIANA

Presented before A.I.S.E., Chicago District Section, May 7, 1940



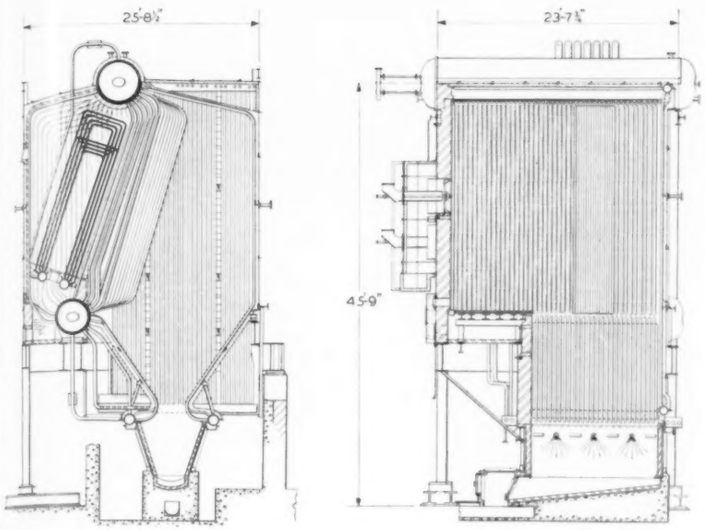
Sectional views of boiler, rated at 141,000 lb. per hour and fired with powdered coal.

▲ THE purpose of this paper is to give you the engineering developments in the preliminary study, construction, erection, and early operation of an 800 lb. per sq. in. steam topping generating station with the necessary auxiliaries. Detailed performances of all these various pieces of equipment will be omitted as much as possible, especially where that information is practically standard and can be obtained from the equipment manufacturers. The necessary auxiliaries include a complete modern water treating plant designed and operated with practically no condensate return. Detailed information will be given regarding the water treating plant.

The officials of our company recently decided to erect a new hot strip mill with other necessary auxiliary equipment. The approximate cost was about $12,000,000 to $15,000,000. Expected increase in power load was about 15,000 kw. It was thought at first that the power could be economically purchased, but after negotiations with the public utility company were started, it developed quite rapidly that it would be more economical to generate the power ourselves. Our power house had two 10,000 kw. and two 5,000 kw. turbine-driven generators installed in place. The boiler house, however, did not have sufficient steam generating capacity to operate all the generators at the same time. In comparing the cost of purchased power and generating power, we had, therefore, to compare the cost of purchased power against the cost of additional steam equipment with the topping turbine unit. This would then leave the fixed charges on most of the generating equipment out of the calculation, and it would not be necessary to show a return on that portion of the investment. Under these conditions it was rapidly proven that it would be more economical to increase the steaming capacity and generate our own power than it would be to purchase power. This comparison is very distinctly different from ordinary circumstances where a direct comparison is made between buying and generating power.

Inasmuch as savings from the new installation would vary with mill operations, particularly the hot strip mill, an expected return on the investment was calculated and listed for each estimated per cent mill operation; for example, mill operations were estimated at 30 per cent production, 50 per cent production, 70 per cent production, and 90 per cent production, and the corresponding savings computed. The management, therefore, had the opportunity to judge which specified mill operation would nearly fit the actual conditions and whether the investment should be made in the new steaming equipment.

In regard to the choice of the new steaming equipment, two schemes were considered. One of these was to furnish three high pressure boilers and no topping turbine. Naturally the operating man's viewpoint would favor three boilers. With three boilers he would have more flexibility, and more of an opportunity to use one of the boilers as a spare. The boilers could possibly be operated at full pressure and the steam sent through reducing valves, or they could be operated at the present 200 lb. pressure, discharging increased amounts of steam into the steam headers. Boilers under these conditions would have given increased capacity, increased efficiency, and would also have given the operating man a certain amount of leeway. The second idea was to purchase two high pressure boilers with a topping turbine unit; this would result in two boilers being at full load practically all the time with no spare equipment and no time out for cleaning. Time for cleaning, when necessary, would have to be found when mill operations were reduced. Also, the topping turbine, according to this scheme, would be producing additional power at an extremely cheap cost, a feature which would be absent from the first plan. The operating man's viewpoint differed greatly from the banker's



viewpoint. The latter viewpoint kept the investment working as nearly continuously as possible, and took chances on breakdowns; this idea was accepted. Two 141,000 lb. per hour boilers were bought for one fuel only, powdered coal. Powdered coal was chosen because at some future date it might be deemed advisable to use a gaseous fuel, either blast furnace gas, natural gas, or coke oven gas. The powdered fuel combustion chamber naturally is the only design which would fit coal or gas.

The pressure in the present headers is 200 lb. per sq. in., and the total temperature 500 degrees F. The choice of the operating pressure of the boilers was so made that steam could be expanded through the topping turbine and exhausted into the low pressure header with the least attention to de-superheating. The pressure and temperature determined upon was 800 lb. per sq. in., with a total temperature of 750 degrees F. The 800 lb. steam has three sources of outlet: the two feed pumps, the topping turbine, or the reducing valve. All three of these discharge into the 200 lb. steam header.

COMBUSTION CONTROL

Combustion control, as applied to the two 141,000 lb. per hour capacity, 800 lb. pressure integral furnace boilers, regulates fuel feed and air supply in accordance with changes in load as measured by slight variations in steam pressure. It continuously maintains combustion economy by automatically readjusting air supply in accordance with the steam flow-air flow ratio.

Air supply is regulated by controlling the speed of a turbine-driven forced draft fan and by regulating a louver damper in the secondary air duct. Fan speed is controlled by a control valve in the steam line to the turbine and damper position is regulated by a air-operated control drive. Both of these devices operate in accordance with load requirements as measured by the master steam pressure controller and they are both automatically adjusted in accordance with combustion requirements as measured by the boiler meter. Air

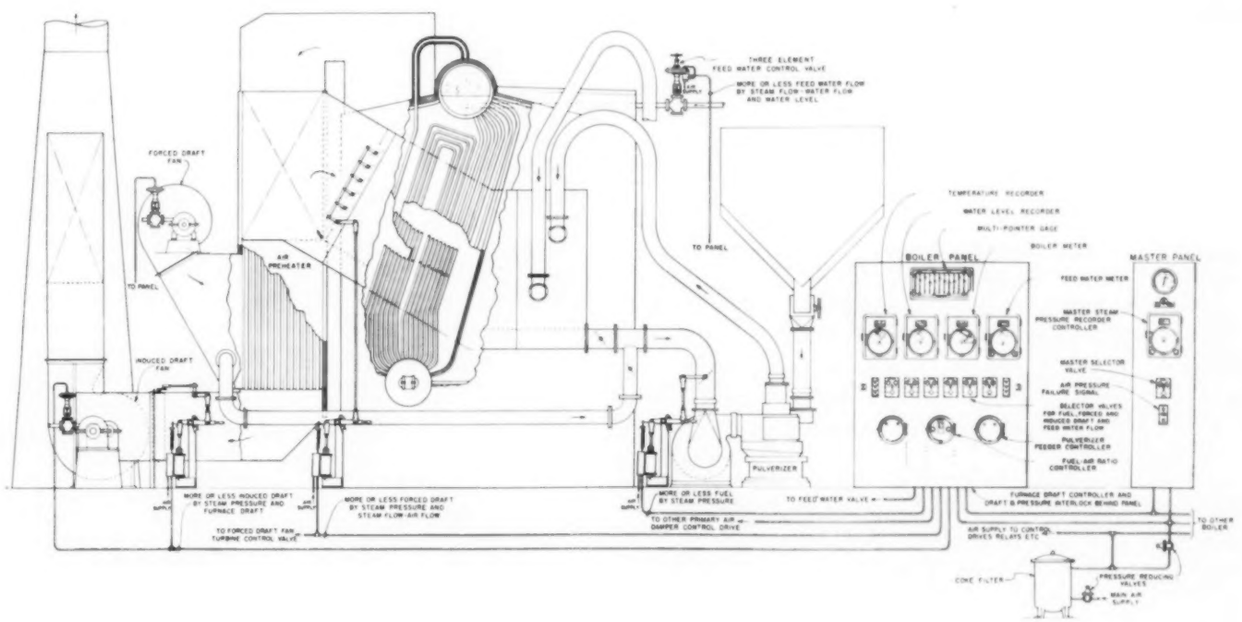
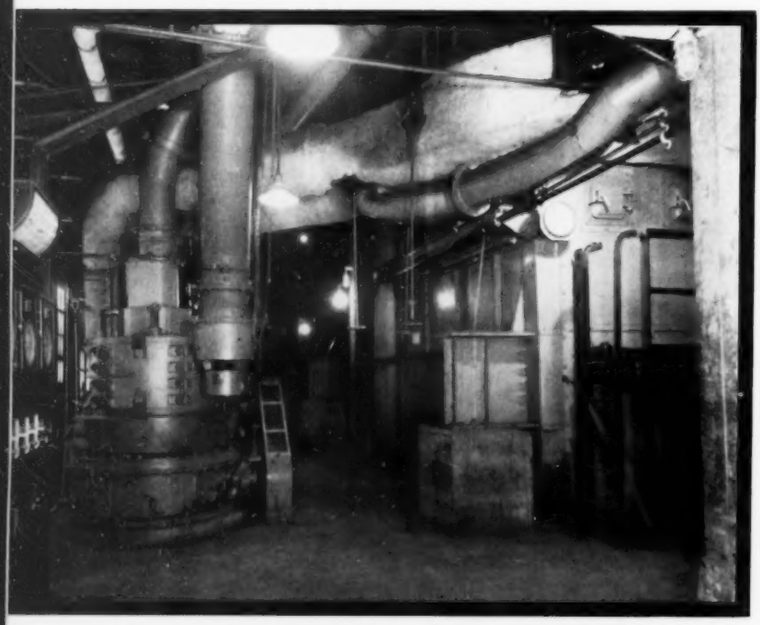

THREE ELEMENT FEED WATER CONTROL VALVE
MORE OR LESS FEED WATER FLOW BY STEAM FLOW-WATER FLOW AND WATER LEVEL
FORCED DRAFT FAN
AIR PREHEATER
TO PANEL
INDUCED DRAFT FAN
TEMPERATURE RECORDER
WATER LEVEL RECORDER
MULTI-POINTER GAGE
BOILER METER
BOILER PANEL
MASTER PANEL
FEED WATER METER
MASTER STEAM PRESSURE RECORDER CONTROLLER
MASTER SELECTOR VALVE
AIR PRESSURE FAILURE SIGNAL
SELECTOR VALVES FOR FUEL, FORCED AND INDUCED DRAFT AND FEED WATER FLOW
PULVERIZER FEEDER CONTROLLER
FUEL-AIR RATIO CONTROLLER
PULVERIZER
MORE OR LESS INDUCED DRAFT BY STEAM PRESSURE AND FURNACE DRAFT
MORE OR LESS FORCED DRAFT BY STEAM PRESSURE AND STEAM FLOW-AIR FLOW
MORE OR LESS FUEL BY STEAM PRESSURE
TO FEED WATER VALVE
TO FORCED DRAFT FAN TURBINE CONTROL VALVE
TO OTHER PRIMARY AIR DAMPER CONTROL DRIVE
FURNACE DRAFT CONTROLLER AND DRAFT & PRESSURE INTERLOCK BEHIND PANEL
AIR SUPPLY TO CONTROL DRIVES RELAYS ETC
TO OTHER BOILER
COKE FILTER
PRESSURE REDUCING VALVES
MAIN AIR SUPPLY

Diagram showing the complete system of combustion control applied to the boilers.

loading pressures established by these meters as a measure of load and combustion requirements are coordinated by an averaging relay (one for each boiler) which sends a final loading or control pressure to the diaphragm-operated valve and to the air cylinder control drive. This final control pressure is sent through a fuel-air ratio controller which compensates for the number of pulverizers in operation.

Fuel control is effected by control drives which regulate primary air to each of the pulverizers in accordance with the air loading pressure established by the master steam pressure controller. A pulverizer feeder controller for each pulverizer maintains the coal level always at the correct value for the rate of fuel delivery.

Furnace draft is controlled by positioning the uptake damper and by regulating the speed of the induced draft fan. As in the case of air supply control, these



View of boilerhouse, showing pulverizer and feed lines, with control panel at extreme left.

factors are positioned primarily in accordance with the load on the boiler and are then readjusted to secure the exact draft pressure desired.

Manual-automatic selector valves permit remote manual operation of the primary air dampers for fuel control and of the forced and induced draft fans together with their dampers at any time. In case of air pressure failure, direct manual control of the dampers and valves can be obtained through the operation of hand levers provided on the control drives.

FEED WATER CONTROL

Three-element feed water control is installed on these units to proportion the flow of water to the boiler so that it equals the steam flow from the boiler by actual measurement. Any slight readjustments which may be necessary to maintain the desired boiler water level are made by the boiler drum water level recorder-controller.

Measurement of the actual rate of water flow as provided in the three-element control system prevents variations in excess pressure of valve characteristics from affecting the water level. No differential pressure valve is necessary. Since the feed water valve is positioned directly from the relation of water flow to steam flow, any variations from the proper relationship are immediately corrected without the necessity of waiting for a reflection in the water level.

A manual-automatic selector valve is provided on the boiler panel so that the feed water control valve may be manually operated from this point if desired. The valve may also be operated manually by means of a hand jack in case of air pressure failure.

The operating medium employed by these control systems is compressed air at 35 lb. pressure. By the use of receiver capacity, the system is insured against sudden failure of the compressed air operated drives. An air pressure failure alarm is provided to warn operators when the compressed air storage drops below a specified figure. This warning gives ample opportunity to switch over to an emergency source of compressed air, or if necessary to hand control, before operation is impaired in any way.

BOILER WATER TREATMENT

In order to insure good operation of the high pressure boilers it was necessary to decide upon the proper water treatment. At the present stage of development of modern power plants it is never necessary to decide whether the water should be treated or not treated, but how it should be treated. No condensate return was available. The first study was an investigation of the treating plant site. It so happened that four reheating furnaces were adjoining the site. Three of these furnaces had been completed and the foundation only of the fourth was in place. It was proposed to build the water treating plant on this foundation, which, naturally, consisted of a heavy concrete pad which had been designed to support a heavy weight. The dimensions of the concrete pad were, therefore, the ground floor dimensions of the water treating plant. This restriction on the size of the water treating plant resulted in the very ingenious and, to a certain extent, complicated arrangement of the water treating plant, machinery, filters, and other accessories.

The design of the feedwater treating system involved the rather unusual problem of providing 100 per cent treated make-up water for two boilers operating at 800 lb. per sq. in. and also for 25 boilers operating at 200 lb. per sq. in. Although the high pressure units would require a better grade of water, it was considered impractical and uneconomical to install two plants to

satisfy these requirements, particularly since the eventuality existed that the low-pressure station might be replaced by additional high-pressure units.

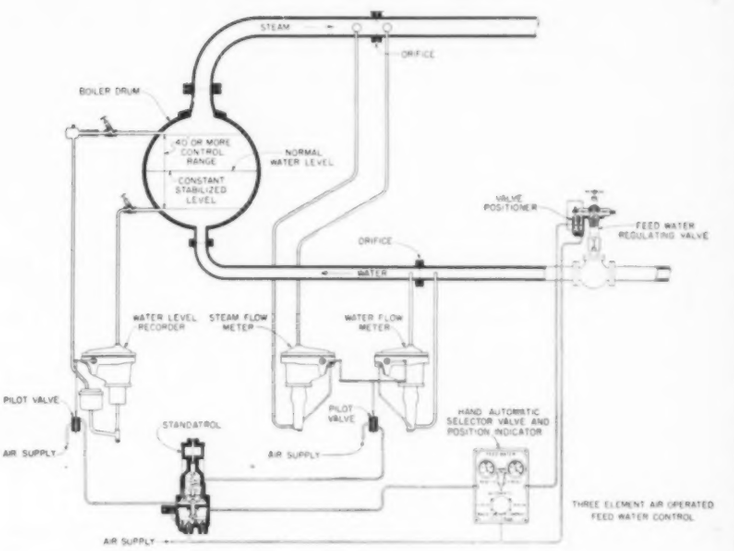
The water supply available was water from Lake Michigan, highly contaminated by both sanitary and industrial wastes. Considerable amounts of domestic wastes are discharged into the lake in the vicinity of the company's intake, and the water is also contaminated to an appreciable extent by oil. Part of the supply is first used for cooling water and is contaminated by products from the company's plant.

In evaluating the means by which the raw water could be best prepared for use in the high-pressure boilers, three distinct methods of treatment were considered:

A. This system consisted of preliminary softening and coagulation for removal of turbidity and silica in a cold process system followed by secondary phosphate softening and deaeration in a hot process softener, and filtration through pressure filters. In order to prevent accumulation of phosphate deposits in the feedwater pumps, piping and high-pressure heaters, the pH of the filtered effluent was to be reduced by acid. Internal boiler treatment by means of phosphates was also to be provided. The advantages of such a system would be (1) elimination of an outside deaerating heater, (2) the small installation space required, (3) the recovery of all wash water used, (4) the low hardness of the treated water and corresponding small amount of sludge in the boilers. Disadvantages were (1) lack of flexibility of operation due to the necessity for complete outage of the secondary softener for repairs, as against an outage of 20 to 25 per cent of the plant at one time if zeolite units were used, (2) the necessity for adding sulphuric acid directly ahead of the feedwater pump, (3) need for expensive acid feed controls and extremely careful operation, (4) the possibility of acid over-treatment resulting in excessive corrosion, (5) necessity for using pressure filters instead of gravity units, increasing the operating difficulties and (6) space limitations which would probably necessitate double-deck pressure filters, further complicating the operation. This limitation of space was a decisive factor in the final determination of the system to be employed.

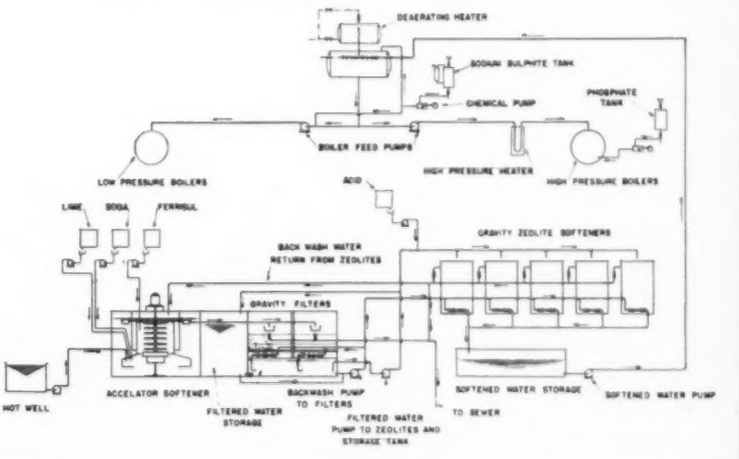
B. This system consisted of softening by lime and soda and deaeration in a hot process softener, with coagulation and silica removal by magnesium sulphate. Maximum reduction in hardness was to be effected by the return of boiler blow-down to the reaction tank so as to maintain a high soda excess. The softened effluent was to be filtered by means of double-deck pressure filters. Secondary phosphate treatment was to be added directly to the high-pressure boiler drums. While this system would have been somewhat less costly to install and would have required less space for installation, there was not adequate experience with this system with the high make-up and boiler pressures specified. In addition, such a system would be difficult to control and would provide less flexibility and less complete hardness removal than the other systems considered, with the result that larger quantities of sludge would be deposited in the boiler.

C. This scheme, which was finally adopted, consisted of preliminary softening by lime and soda-ash and coagulation for silica removal, followed by filtration through gravity anthracite filters and complete softening by carbonaceous zeolites. Deaeration in a secondary heater and internal treatment with phosphate for the high-pressure boiler completed the system. The most obvious advantage, and a large factor in the selection of this system, was the complete flexibility provided under all operating conditions. In addition, this system insured a minimum residual hardness in the final effluent, eliminating the danger of deposits in feedwater



Schematic drawing showing the arrangement of feed water control applied to the boilers.

Flow diagram of water softening plant, which is designed to produce 1,000,000 lb. of feed water per hour.



pumps, piping, economizer tubes, etc., and insuring a minimum amount of sludge deposition in the boiler drums. In addition, relatively large storage of filtered and softened water was provided and the possibility was presented of future conversion of certain of the zeolites from the sodium to a hydrogen cycle, thus affording a reduction in total solids.

The system is so designed as to provide a maximum of 1,000,000 lb. per hour of soft, deaerated feedwater. The raw water flows by gravity to a recently developed apparatus in which reaction, flocculation and sedimentation are carried out. At this point lime and soda-ash are added to previously precipitated sludge and the whole intimately mixed with the incoming raw water. Ferric sulphate is then added for silica removal and to coagulate suspended solids. Clarification proceeds as the water rises through a blanket of sludge, which is maintained at a constant elevation and an optimum density by intermittent withdrawal, and the effluent is taken off through a suitable trough.

From the reaction tank the partially softened water flows by gravity to a battery of four 10 ft. x 18 ft. rectangular gravity anthracite filters. Filtration rates are controlled by suitable float and orifice boxes discharging into a clear well of 30,000 gallons capacity, located beneath the filters. Filtered water for backwashing is obtained from a storage tank of 62,000 gallons capacity, located beneath the zeolite softeners. This storage tank is kept full at all times, but supplements the filtered water clear well if the level in this compartment drops below a certain point.

To reduce the alkalinity and pH of the softened filtered water prior to final softening by the carbonaceous zeolites, sulphuric acid was originally added directly to the clear well beneath the filters and mixed with the water by a series of baffles. The pH of the zeolite influent is maintained between the limits 7.0 and 8.5. This arrangement is being replaced by an acid mixing section in the pipe line discharging filtered water to the zeolite softeners.

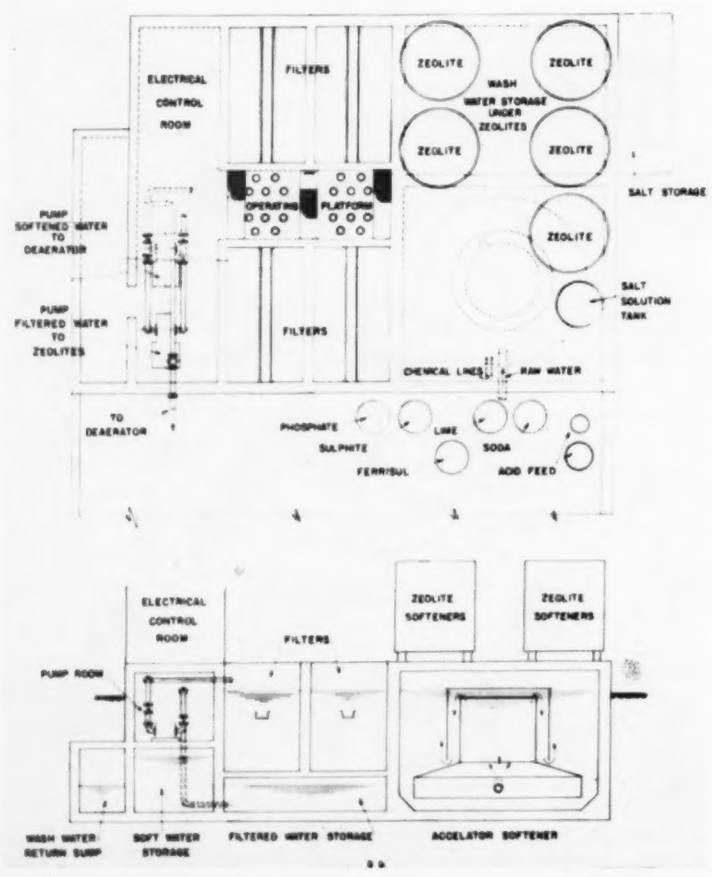
The acid treated filtered water is then pumped to a battery of five 10 ft. diameter x 12 ft. high gravity zeolite softeners of the carbonaceous type and these in turn discharge into a steel lined storage tank of 18,600 gallons capacity, located beneath the pump room. Filtered acid-treated water taken from the aforementioned storage tank is used for backwashing the units. The wash water from both the zeolites and anthracite filters flows to a sump, whence it may be pumped either to the sewer or to the inlet chamber of the reaction tank. Acid-treated filtered water is used for rinsing the softeners and is then discharged directly to the sewer. The backwashing and rinsing rates are controlled by float and orifice boxes.

From the soft water storage tank, water is pumped to a deaerating heater and storage tank. At this point sodium sulphite is added to remove all traces of oxygen and to maintain an excess of sulphite in the boiler water. Deaerated water is then pumped to the low-pressure generating station or through a high-pressure heater to the high-pressure boilers. Di-sodium phosphate is added directly to the top drum of the high-pressure units in order to precipitate as a sludge any traces of hardness still remaining.

The concentration of solids in the boiler water is controlled by a continuous blowdown discharging into flash tanks in the 200 lb. and 3 lb. systems. Residual blowdown water then passes through a heat exchanger, imparting its heat to the soft water being pumped to the deaerator, and is discharged to the sewer.

All chemicals used in the treating process are proportioned to the flow to be treated. Lime, soda, ferric sulphate and acid are proportioned to the raw water flow to the reaction tank; sodium sulphite is proportioned to the flow to the deaerating heater and phosphate is proportioned to the boiler feedwater.

Plan and sectional views of treating plant, which was laid out to fit an existing foundation.



OPERATING RESULTS

About September 25, 1939, the water treating plant was ready to start up. A few weeks previous our department had secured the services of a number of recent college graduates. It was deemed advisable that this type of personnel be employed for the water treating plant, and at least 75 per cent of the men in the water treating plant at the start and at the present time, have college degrees, some in chemistry, others in mechanical engineering.

After the water treatment plant was started up and the high pressure boilers with their auxiliaries were ready to start, it was found that our fuel department would also have to do this job. We had a number of men who were experienced in the combustion control equipment and had considerable boiler house experience, and these men were selected to operate the panel board, which controls the two boilers and the new auxiliary equipment. We operated the boiler house for about two months, after which time the regular operating personnel had become familiar with the control equipment, and they took over the work.

In many cases where float-actuated equipment was in service, it was necessary to provide a man to operate manually in case of sticking floats. This difficulty was overcome after about three weeks of operation. While a number of operating difficulties have been encountered since the plant was put into service, the records demonstrate that a feedwater of excellent quality has at all times been available for the boilers and the composition of the concentrated boiler water has been maintained within the recommended limits.

A number of boiler inspections have been made since the plant was put into operation, and in each case the boiler and tube surfaces were found to be very clean, free from scale or any evidence of corrosion. An analysis of a deposit from a generating tube in No. 1 boiler on December 3, 1939, showed the following constituents:

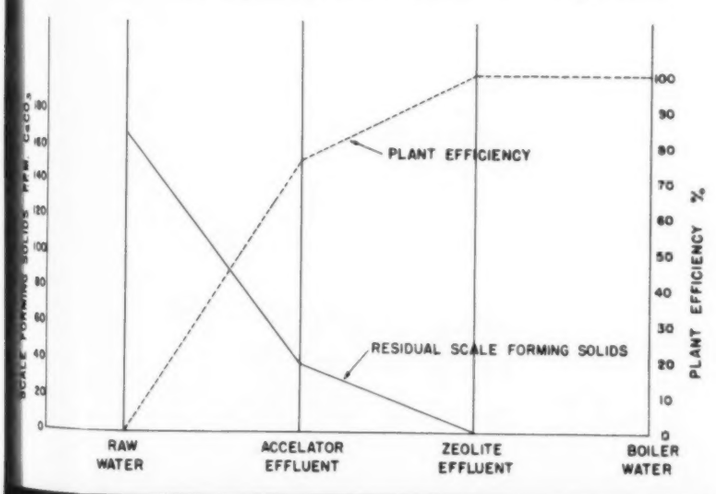
SiO_2	4.72 per cent
Insoluble iron	1.08 per cent
Soluble iron	14.62 per cent
Alumina	0.38 per cent
Calcium oxide	24.37 per cent
Magnesium oxide	20.18 per cent
Phosphates—qualitative test showed presence of large quantities.	

In the operation of a plant of this type, equipped with such varied types of apparatus, it must be anticipated that numerous difficulties must be overcome. Until recently it has been difficult to maintain the chemical feed to the reaction tank proportional to the raw water flow when sudden changes in load occurred. Successful operation of the tank was thereby impeded. It was also found that when the acidified wash water was returned to the flocculating compartment for re-treatment, as originally planned, the sudden heavy flow greatly upset the sludge equilibrium and was usually followed by the passage of large quantities of very turbid water to the filters. Consequently, the wash water return line was closed off and all water directed to the sewer.

Difficulty was also experienced with the acid feeding system and at times the pH of the influent to the zeolite softeners had been so high as to cause apprehension over the possible deterioration of the zeolite material. It is now proposed to add the acid at a different point in the system where more adequate mixing is available and, in addition, certain changes have been made to the acid feeding equipment. Operation was made additionally difficult by the excessive time required to regenerate the zeolite softeners, but modifications to the procedure have resulted in improved results. The continuous feeding of sufficient phosphate to precipitate the residual hardness after zeolite softening was hindered by the poor operation of the solenoid valves controlling the phosphate feed. New valves, better protected from contact with the phosphate solution, have largely remedied the situation.

On the whole, considering the complexity of the system, plant operation has been quite satisfactory and the condition of the boiler surfaces at each inspection demonstrates that, despite a number of difficulties and annoyances encountered, the feedwater has continued to be of excellent quality. Various small changes planned by our engineers and the manufacturers' service departments are expected to largely eliminate the difficulties described above.

Chart showing progressive hardness removal and plant efficiency through the steps of the treating process.



FUEL

After the boilers had been run approximately five months, we had practically all of the difficulties ironed out, and it was then desirous to operate on cheaper coal. The coals used previous to the installation of the high pressure boilers delivered at approximately $3.50 per ton. The coal which we desired to burn delivered at approximately $2.55 per ton. This kind of coal is commonly known as carbon, and should be classed as all coal under ¼ in. size. After using this coal for approximately a month and one-half, the summer months came on, and there is every indication at the present time that this kind of coal is quite scarce. Certain varieties of this coal which have a high moisture, high ash, or high sulphur, are not desirable.

We are able to operate very successfully with a coal having approximately 10 per cent moisture, 14 per cent ash, and 3½ per cent sulphur. Coals having high sulphurs and higher ashes are, so far, not so successful. Especially with the higher sulphurs, we have found considerable trouble with slagging on the tubes. At the present time, considerable study is going on regarding the coal supply which is available in the summer months.

ADVERTISING PAGES REMOVED

"SHUTDOWNS ON OUR PLANER CAUSED PRODUCTION 'HEADACHES'

...until we solved the problem by installing BUSS Fuses"

...So Says, *Chief Electrician*

A. Robinson of Taylor Wharton Iron & Steel Company, Highbridge, N. J. and he continues, "We have a metal planer driven by a DC motor that formerly was protected by a 50 ampere breaker. Rough spots on castings caused a momentary overload on the planer and the resulting surge on the motor circuit frequently caused the breaker to open.

These recurring shutdowns were a "headache" as they interrupted production and disrupted shop routine. Several months ago we decided to replace the breaker with BUSS Super-Lag Fuses. To date we have had only one blow. We think this phenomenal, as we are getting safe protection plus the practical elimination of needless shutdowns."

WHY NOT TAKE A TIP FROM MR. ROBINSON AND WIPE OUT USELESS SHUTDOWNS AS HE DID?

Isn't it just a waste of money to permit any plant to suffer from useless shutdowns—when you can get fuses that will greatly reduce or eliminate entirely, shutdowns caused by fuses blowing needlessly?

Naturally there are sound reasons why BUSS Super-Lag fuses prevent needless blows . . .

The design of the BUSS FUSE-CASE is such that it reduces to a minimum any chance for poor contact to develop in the fuse itself.

Hence heating from poor contact—that so often causes needless blows—is practically wiped out.

The Super-Lag development in the FUSE-LINK gives BUSS Fuses a retarded blowing point—or long time-lag that permits them to hold on without blowing when harmless overloads are piled on circuits already loaded.

In your plant, BUSS Fuses will . . .

Abolish wasteful shutdowns caused by needless blows . . . Keep circuits from being thrown out of service . . . Keep machines running and workers on the job . . . and will have an unusually long life even under hardest service conditions.

To get quick results

Pass the word along to change all stock and purchase records so that from now on all fuses installed shall be BUSS Super-Lag Fuses. Then you will have action that means money saving.

Bussman Mfg. Co., St. Louis, Division McGraw Electric Company.

BUSS Super-Lag FUSES

STRAIGHT-LINE SHEET GALVANIZING

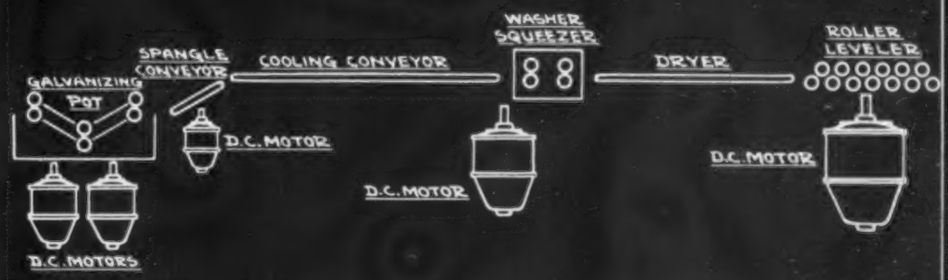
WITH *Synchronized* RELIANCE MOTOR-DRIVE

Tackling the drive problem with the question "What can we get the motors to do besides supply power?" brought interesting results on the galvanizing line shown here. . . The No. 1 result was to supply a speed range of more than 6 to 1 electrically. This simplified driving parts, saved on first cost and provided finger-tip control. With this smoothly running drive workmen can keep the line moving at a top-notch pace, sure of producing sheets with the desired spangles and free from scratches.

Such results lend weight to our suggestion that when you go into a huddle over a straight-line processing job you invite a Reliance man to join you. He can understand your signals, and you will find him accustomed to teamwork.

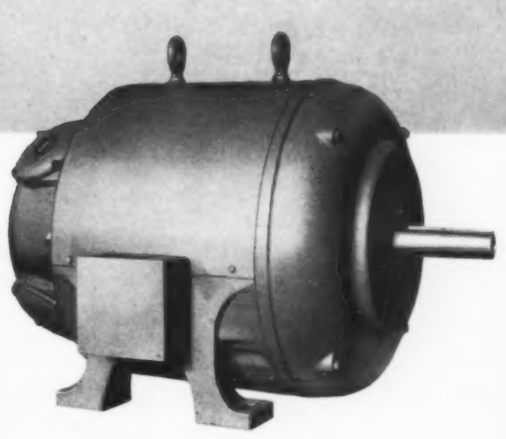
★ ★ ★

Motor-drive is MORE THAN power



Here's another layout typical of those meeting today's ideas of straight-line processing of sheets and strip. Specially engineered for the work, a Reliance Synchronized Drive takes a real part in accomplishing those things which influence favorably both the production rate and quality. . . . Motors are held in step so that rolls and other sections of the line perform in correct relation to each other. Speeds of the first four motors can be changed simultaneously from a single push-button. The speed of an individual motor can be adjusted separately. Each set of rolls can be started, stopped and reversed independently of the others—a big advantage in case of cobbles.

These sheet galvanizing lines equipped with Reliance Synchronized Drive have operated successfully over a range of 10 to 135 ft. per minute. By pressing a "fast" or "slow" button the operator can speed up or slow down the entire line in perfect synchronism.



Enclosed Fan-cooled Type T Reliance D-c. Adjustable-speed Motor as used for galvanizing lines. This protected type of motor is used as an added safeguard against corrosive fumes and dust.

RELIANCE ELECTRIC & ENGINEERING COMPANY, 1087 IVANHOE ROAD, CLEVELAND, OHIO

RELIANCE A-C D-C MOTORS

SOUTH WORKS MATERIALLY ENLARGES FURNACE AND QUENCHING FACILITIES

▲ The steadily increasing demand for heat treated alloy steels has necessitated enlarging furnace and quenching facilities at the South Works plant of Carnegie-Illinois Steel Corporation, Chicago, Illinois. A new, electrically-heated, bell type heat treating furnace recently has been installed there together with a second quenching tank, giving three furnaces and two quenching tanks equipped to operate under full automatic control.

With this equipment, the company is in a position to correlate the findings of laboratory research and data from the testing departments with commercial practice and consistently ship material with uniform physical properties and microstructure in accord with the needs of the user.

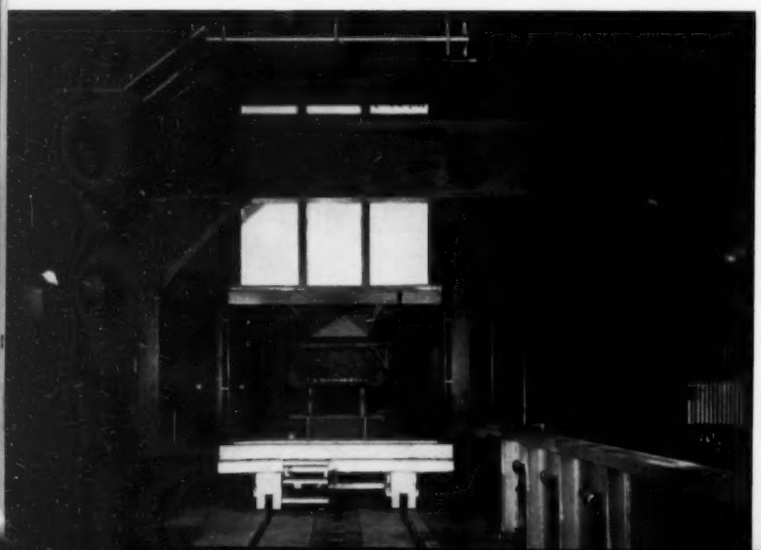
The furnaces are designed to handle up to an 18,000-lb. load, taking bars up to 10 in. in diameter and 30 ft. long or plates up to 52 in. wide. The load rests on a series of heat-resisting alloy grids 21 in. above the car bottom. A double row of heat elements on each side wall and a triple row in the roof of each furnace provide rapid, uniform heating of the load, the design assuring heating of the charge from the bottom as well as the top.

Design and heating capacity of the furnaces is such that a uniform temperature can be maintained throughout the charge, automatic controls being provided to maintain this temperature. During the cooling cycle the controls are reset manually at prescribed intervals. Rapid, controlled heating with a minimum of scale and a minimum of decarburization is possible in these new furnaces.

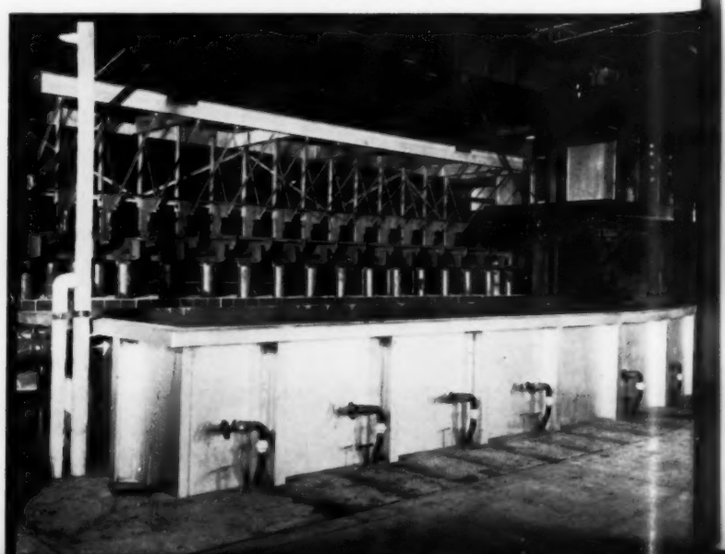
Uniform results depend upon the maintenance of uniform practices and the automatic facilities installed in connection with these heat treating furnaces and quenching tanks makes this possible. The load for any furnace is assembled on a special charging table in a single layer in the case of heavy bars or in a double layer for lighter sections. When the charge is ready, the furnace bell is raised and the furnace car run out under a traveling crane which travels the entire length of the heat treating building. This crane is fitted with a series of carrier arms spaced to fit between the supporting grids on the furnace car, which conform to the spacing on the charging table. The load is transferred as a unit on these cars to the furnace car. This is then run back under the bell, which is lowered and the heating cycle started.

All operations are controlled by a single operator from the control pulpit, so located that the operator has a clear view of all manipulations. The electrical system is so arranged that any operation may be controlled manually or any sequence of operations may be set to advance automatically. Eleven such sequences may be pre-set. The operator chooses the desired cycle by setting a selector switch on the control panel and then closes a master control switch, after which the mechanism functions automatically. This is particularly important in connection with treatments in-

A complete furnace load may be quenched in oil within 90 seconds or in water within two minutes from the time the bell is raised as shown in this view.



Crane grapple removing bars from car after treatment in furnace shown at left. The quenching tank shown in the foreground of this view is capable of quenching from as high as 2000 degrees F.



volving quenching, and a typical sequence runs as follows:

1. The crane is brought to its stand-by position by manual control.

2. The selector switch is set for the desired cycle for quenching the load and the master control switch closed, providing for the following automatic operations:

a. The furnace bell rises.

b. The furnace car is moved into position under the crane runway.

c. The crane moves into position over the car with the carrier arms in position beneath the charge.

d. The charge is lifted, carried to position over the quenching tank and lowered into the quenching medium.

e. The charge is alternately raised and lowered in the quenching medium for a predetermined length of time at a rate best suited to the steel being quenched.

f. At the completion of the cycle the crane comes to rest over the quenching tank.

3. The selector switch is then set for the next automatic cycle for charging the load into the tempering furnace, which has been set for the desired temperature.

a. The furnace bell of the second furnace rises.

b. The furnace car moves into position under the crane runway.

c. The crane places the charge on the furnace car and moves back to clear the car, coming to rest in its stand-by position.

4. The furnace car is then moved back into position under the furnace bell, which is lowered. These operations are both under manual control.

The quenching tanks, one being used for oil and the other for water, each have a capacity of 18,000 gallons and are large enough to permit the crane to submerge the full load completely. In this way each piece receives practically an individual quench, but uniformity of treatment is maintained regardless of the number of pieces in the order.

A wide variety of alloy steels are heat treated at South Works, ranging from the low alloy grades up through the austenitic stainless steels. The furnaces are designed to operate at temperatures as high as 2000 degrees F. with automatic control to maintain close temperature regulation. This permits quenching from as high as 1950 degrees F. as in the case of this company's stainless steel, and assures ample heating capacity when quenching from lower temperatures. The set-up is such that a complete furnace load may be quenched into oil within 90 seconds, or in water within two minutes from the time a furnace bell is raised.

Quenching bath temperatures may be controlled by circulating the liquids through heat exchangers, permitting the bath to be warmed if the liquid is too cold during winter months, or cooled as may be necessary when operating on short cycles or from high temperatures.

Although the equipment is largely used for quenched and tempered material, it is adaptable for use in annealing, normalizing, normalizing and tempering, stress relieving, or spheroidizing. Quenching and drawing operations are ordinarily confined to bars.

Automatic equipment assures close control of heating time, permits more accurate control of heat loss between the time the load leaves the furnace and the moment it is first quenched, makes possible uniform quenching, and speeds up production as well as assuring uniformity at all times. These features are all embodied in the South Works heat treating installation, which is a part of the modernization program now in process throughout the Carnegie-Illinois Steel Corporation plants as well as other subsidiaries of United States Steel Corporation.

COIL HANDLING MAGNET SHOWS HIGH CAPACITY

▲ Recently one of the heaviest loads of coiled strip steel was lifted and conveyed by a coil handling magnet manufactured by the Electric Controller and Manufacturing Company. This coil handling magnet, installed at the Middletown plant of the American Rolling Mill Company, lifted a total load of 56,600 lb. (27,770 lb. coil and 27,990 lb. coil, 840 lb. tare) through two wood spacers of 7/16 in. total. Coils were of 55½ in. outside diameter, 30 in. inside diameter, height 61 in. each. This lift was made at 80 per cent current with magnet hot. The magnet used for this test lift is normally rated to lift a finished coil weighing 40,000 lb., with a safety factor of 50 per cent as indicated by this test.

This coil lifting magnet is shown lifting a total of 56,600 lb. The capacity of this magnet is 40,000 lb. with a 50 per cent safety factor.

To meet the trend toward bigger and heavier coils of strip steel, the Electric Controller and Manufacturing Company is now building an order of five larger magnets of similar design for handling 60,000 lb. coils with a 50 per cent safety factor. These magnets will be used shortly in a strip mill installation now in the process of being remodeled to turn out the heavier coils.

ANNOUNCE MERGER OF COKE PLANT BUILDERS

▲ Semet-Solvay Company announced the acquisition of the Wilputte Coke Oven Corporation, thereby combining the ability and experience of Semet-Solvay Company, Semet-Solvay Engineering Corporation and Wilputte Coke Oven Corporation, builders of coke ovens and by-product recovery apparatus and gas generating equipment.

LUBRICATING SYSTEM FOR SMALL MACHINES

▲ A new development in centralized lubrication is the "Dualine Jr." system, announced by Farval Corporation. The new unit operates on the same piston displacement principle of measurement employed for the past

12 years in the large Dualine systems on heavy machines, but size has been greatly reduced to provide correct application to small machine tools and other equipment. In keeping with smaller pumps and measuring valves, the manufacturer has produced a corresponding line of fittings, hose, couplings and other accessories.

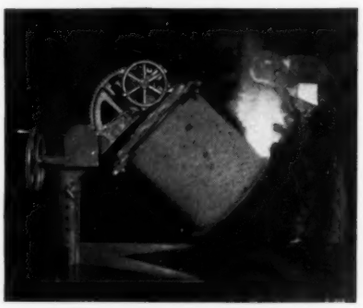
The Dualine Jr. valve has but two moving parts. It contains no springs and no check valves and is fully adjustable. Positive delivery of lubricant to each bearing is made independently of the judgment of the oiler or his ability to reach all bearings regularly.

The new lubricating system will reduce labor of oiling; eliminate waste of lubricant; increase production; reduce repairs and maintenance; and prolong life of equipment.

NEW SIZE POSITIONER FOR WELDING STANDS

▲ Recently added to Cullen-Friestedt Company's line of welding stands is a new size positioner, capacity 1,200 lb. Like other positioners of this line, the new Model 12 can be tilted a total of 135 degrees from horizontal and table can be revolved through a full circle regardless of angle of tilt. The table is removable for attachment of special jigs or fixtures and is adjustable in height. By mounting the positioner operating mechanism on a special base, extremely large and bulky work can be fully rotated when tilted either vertically or a total of 135 degrees without any interference from floor or pedestal mounting.

This new unit can be furnished fully powered with independent motor and



controls for table tilt and table rotation. Power for table rotation can be furnished with either constant or variable speed drive.

It is claimed that the universal adjustment of table of this positioner reduces the number of passes required, reduces rod consumption and assures a better weld by permitting all work to be done in a horizontal trough. Much welding, hoist and crane time

25 ton - 90'-0" span Cleveland all-welded crane in a modern steel mill

MODERN CRANES ARE

ALL-WELDED

Not just the trolley or the end trucks, but every section of modern cranes is all-welded — including the girders.

It stands to reason that if welding improves some sections of a crane it will improve all sections. For this reason Cleveland has been **all-welding** cranes since 1926.

A large part of the hundreds of all-welded cranes we have built are serving the steel industry. To the best of our knowledge, every all-welded Cleveland crane is still on the job performing like it did the first day installed.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES

ALL-WELDED OVERHEAD TRAVELING CRANES

Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

is saved by positioning assemblies, and, with variable speed power operated table rotation, rod may be held in one position while work is rotated at proper welding speed.

CANTON WORKS INSTALLS TWO ELECTRIC FURNACES

▲ Republic Steel Corporation is installing two 50-ton electric furnaces at its Canton Works in Canton, Ohio. Installation will be started as soon as materials are received and necessary building alterations completed. Installation of the new furnaces also means additional processing and finishing equipment.

The new furnaces give Republic three electric furnaces of 50-ton capacity, three of 25-ton capacity, three of 15-ton capacity, and two of 6-ton capacity. A new 50-ton furnace was put into operation this spring together with a 25-ton furnace which was moved to Canton from Buffalo.

MODERN GAS WASHERS FOR ELIZA BLAST FURNACES

▲ Jones and Laughlin Steel Corporation has awarded a contract to the Peabody Engineering Corporation for the modernization of two blast furnace gas washers, located at the Eliza Furnaces, Pittsburgh Works. The new equipment is scheduled for installation late in September.

DESIGN UTILITY WELDER FOR GENERAL PURPOSES

▲ A new modern all-purpose portable a-c. arc welder designed for all around general utility service and production welding of every type, has just been introduced by the Westinghouse Electric and Manufacturing Company. Standard models operate on either 220 or 440 volts, are completely self contained, and incorporate several distinct new design features.

From 20 to 250 amperes of welding current is available in twenty-seven current steps, with increments properly proportioned to meet the needs of welding with a wide variety of electrode types and diameters. Current adjustment is easy; just select the current desired, insert the bayonet plugs in the proper receptacles and the machine is ready to weld. Current values are clearly indicated in large legible numerals.

Safety is well provided for. A built-in "De-Ion" breaker insures protection against long sustained overloads, such as might occur by accidentally leaving the machine short circuited. This is convenient, too, for disconnecting the machine from the line without having to go back to a service or feeder switch. Open circuit or striking voltage is exceptionally low, being on the order of 80 volts at twenty amperes, and ranging down to 50 volts at the highest current rating.

The welder is completely self-contained, being enclosed in a rugged steel case which is mounted on three

REGISTERS DRAFT, PRESSURE AND DIFFERENTIAL
in
SOAKING PITS
ANNEALING FURNACES
OPEN HEARTHS
SLAB MILLS
HAYS "OT" DRAFT RECORDER
Results in a better product because it gives a correct indication of furnace atmospheres. Built husky enough to stand the severest steel mill conditions yet sensitive enough to register accurately in increments of .0025 in. water. Employs the famous Hays Slack Leather Diaphragm—self sealing—not damaged under sudden excess pressures. Two draft values, two pressure values, two differential values, or a combination of any two of these three values may be recorded. Or a temperature recorder may be substituted for one of these values. Send for descriptive literature. Write to 955 Eighth Avenue, Michigan City, Indiana.
The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

wheels. Thus the machine is portable too. High efficiency, high power factor, and low no-load losses insure maximum operating economies. The welder is furnished complete with all accessories, including welding helmet with lens, electrode holder, all leads, and a 17 lb. assortment of electrodes. Both a three-pronged plug and receptacle for the power lead is included.

LOAD CARRIER TRUCKS FOR LIMITED SPACES

▲ A new truck of the load carrier type with a capacity of 3,000 lb. is now being manufactured by the Yale and Towne Manufacturing Company. A general utility truck, it has been designed to carry all kinds of miscellaneous items, and may be loaded by hand, chain hoist, electric hoist, overhead crane, etc. Small and compact, this material handling unit features a rugged frame of welded steel plate for great strength with minimum truck weight. Light-weight trucks are particularly valuable where loads must be transported over gangplanks, floors, and in elevators of limited capacities. In addition a four wheel steer and small overall dimensions make it excellent for use in narrow aisles and other congested quarters.

For the operator's safety, the control platform is protected by a streamlined bumper.

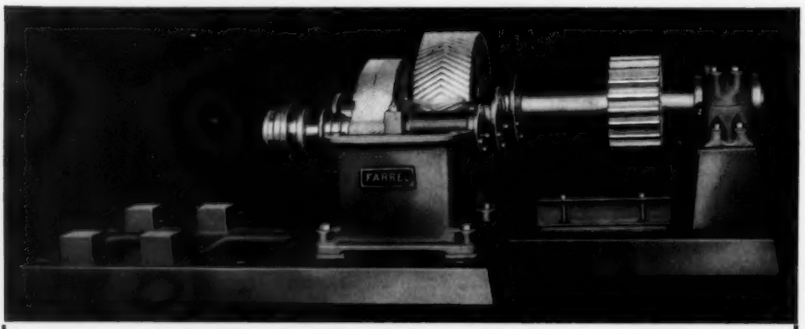
DEVELOP NEW LINE OF PUSH-BUTTON STATIONS

▲ A new line of one- and two-button standard-duty push-button stations has been announced by General Electric Company. These general purpose devices offer improvements in operation, appearance, and ease of installation. They are similar in appearance to heavy-duty stations, and their $\frac{7}{8}$ in. molded buttons are made slightly concave for convenience.

They are protected from accidental operation by guard rings. The words "Start" and "Stop" molded into the front of the buttons are filled with white paint to make them easily readable. Other identification can be provided on separate plates attached to the enclosure directly above the buttons. The new stations are $4\frac{9}{16}$ in. high, $2\frac{5}{8}$ in. wide, and $2\frac{1}{2}$ in. deep, and have ample wiring space.

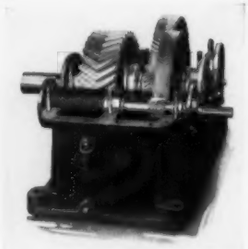
The station enclosure is made entirely of steel and consists of back and cover. The cover is crimped over at the ends to overlap the top and bottom ends of the back, and is held in place by one screw at the top and one at the bottom. Mounting holes for these new stations are in the upper left-hand and lower right-hand corners where there is ample room for inserting the screwdriver.

The contacts are of fine-silver backed by steel. They are arranged to provide a double-break action and are spot-welded to the supporting crossbar. As the contacts close, a rolling action produced by an off-center contact bar causes the contacts to roll slightly. This assures a good contact and tends to prevent welding.



Type DR Unit with low speed shaft extended, assembled with motor bed and outboard bearing.

FARREL GEAR UNITS
Built for Efficient Lasting Performance



Triple reduction unit, ratio 136:1. Note compactness of drive, with the output shaft in line with first intermediate shaft.

Here is a handbook of valuable information for all gear users, giving specifications, dimensions and ratings. Send for Catalog No. 438.

The long-lived efficiency, durability and satisfactory performance of Farrel Gear Units are due chiefly to these features: precision-generated, continuous tooth herringbone gears, proportioned for extra strength and load-carrying capacity to withstand shocks, stresses and wear; anti-friction roller bearings holding the gears in permanent alignment; rigid mountings that eliminate vibration and deflection; and an effective lubricating system.

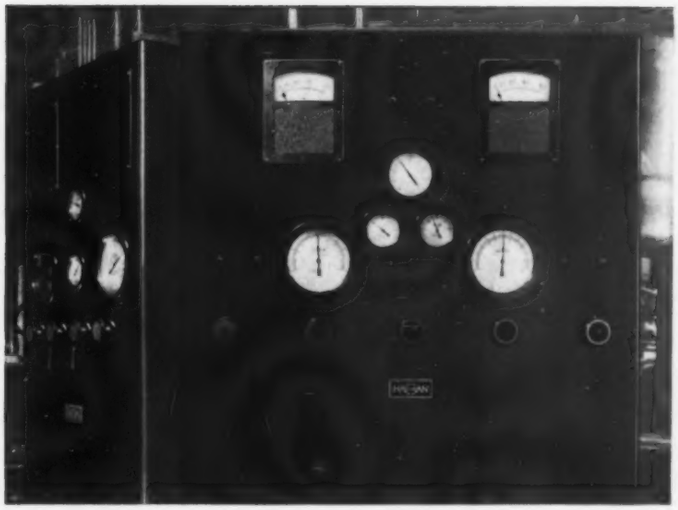
Farrel Gear Units are designed to allow latitude in proportioning their gears to specific conditions of load, speed and service, a flexibility permitting engineering exactness in gear detail.

The complete series of self-contained, totally enclosed gear units meets every requirement for smooth, quiet and efficient power transmission.

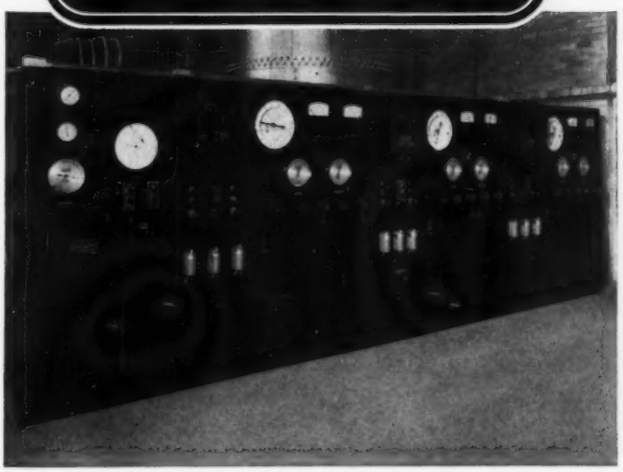
FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS — *The Gear with a Backbone*

Three MAJOR CONTROL INSTALLATIONS AT WEIRTON *-all engineered by Hagan*



1. *Gas Mixer Control* — a "balance wheel" on the Weirton coke-oven gas system. Mixes blast furnace gas and coke-oven gas for low B.T.U. fuel. If the demand for mixed gas becomes greater than the supply, the mixer automatically adds enough natural gas, mixed with air, to furnish the required amount of fuel.



2. *Soaking Pit Control.* Hagan Air-Gas Ratio, Furnace Pressure and Gas Pressure Control on three Rust regenerative soaking pits not only reduces fuel cost substantially, but the more uniform heating produces more uniform quality steel and lowers production costs.

3. *Boiler Control.* The two 400,000 lb./hr. boilers, fired with powdered coal and coke-oven gas, have shown a continuous average saving of 500 tons of coal *per day*. They are completely equipped with Hagan Automatic Combustion Control. A third similar unit is now under construction.

WEIRTON STEEL COMPANY has achieved some remarkable results through the wide use of automatic combustion control. This forward-looking organization is producing better steel at lower cost by the proper application of combustion control to specific operating problems.

No matter what your combustion control problem may be—you can depend upon Hagan engineers to provide the right answer. Just call or write.

HAGAN CORPORATION · 300 ROSS STREET · PITTSBURGH, PA.

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader

ITEMS OF INTEREST

C. H. Manion, chief engineer since 1932 for Follansbee Steel Corporation, was elected vice-president in charge of operations. Mr. Manion has been associated with the corporation and its predecessor, Follansbee Brothers Company, since 1919, serving successively as designer, maintenance engineer, efficiency engineer, and operating engineer. As chief engineer he has been active in planning the company's present modernization program.

A West Virginia University graduate, Mr. Manion, before joining Follansbee, was employed in production and cost work for Wheeling Can Company. Next he became construction and cost clerk, and then field engineer for the Merchant and Evans Company. Subsequently he served successively as draftsman for Tennessee Coal, Iron and Railroad Company and the Whitaker Glessner Company; and as estimator and designer for Wheeling Mold and Foundry Company.

William L. Barr was advanced from the position of maintenance engineer to succeed C. H. Manion as chief engineer for Follansbee Steel Corporation. Mr. Barr, who is 32, was born in Scotland and attended Carnegie Institute of Technology. He has been with Follansbee since 1927, starting as a tracer and advancing through positions as detailer, designer, checker, chief draftsman and maintenance engineer, to his new position as chief engineer.

Charles R. Miller, Jr. has been appointed director of purchases, United States Steel Corporation of Delaware, with headquarters at its Pittsburgh offices, taking over the duties with respect to purchases of **Charles H. Rhodes,** vice-president, who has recently been transferred to Chicago.

Harry H. Lumley, manager of operations in the Duluth district for the American Steel and Wire Company, is being transferred to the Chicago district, where he will be assistant manager of operations. Mr. Lumley has been associated with United States Steel Corporation subsidiaries for over 39 years. Born in Joliet, Illinois, he began working for the Illinois Steel Company in Joliet in March, 1901. In 1910 he was employed by the Minnesota Steel Company, where he worked his way through various positions until in December, 1929, he was appointed assistant to the president. In 1932, when Minnesota Steel was taken over by American Steel and Wire Company, Mr. Lumley was made assistant to the district manager of operations and in November, 1933, acting manager. In December, 1934, he was appointed manager of operations in the Duluth district, which position he held until the present time.

B. E. Pheneger, formerly general superintendent of American Steel and Wire Company's coke works and central furnaces and docks at Cleveland, Ohio, succeeds Harry H. Lumley as manager of operations in the Duluth district. Mr. Pheneger was born in Cleveland and after graduating from Case School of Applied Science with a civil engineering degree, started work with the wire company as a draftsman at central furnaces in September, 1907. He worked his way through the ranks until he was appointed superintendent of the central furnaces in December, 1935, and in October, 1937, was made general superintendent of central furnaces and docks and the Cleveland coke works.

H. A. Byrns, superintendent of American Steel and Wire Company's blast furnaces at Duluth, becomes general superintendent of the Cleveland coke works and central furnaces and docks. Mr. Byrns was born in Cleveland and graduated from Case School of Applied Science with a mechanical engineering degree before joining the wire company as a machinist at central furnaces and docks in August, 1923. Except for a three year period as assistant superintendent of furnaces at the Lorain Works of the National Tube Company, he has been employed by American Steel and Wire Company ever since, having been appointed superintendent of Duluth blast furnaces in September, 1936.

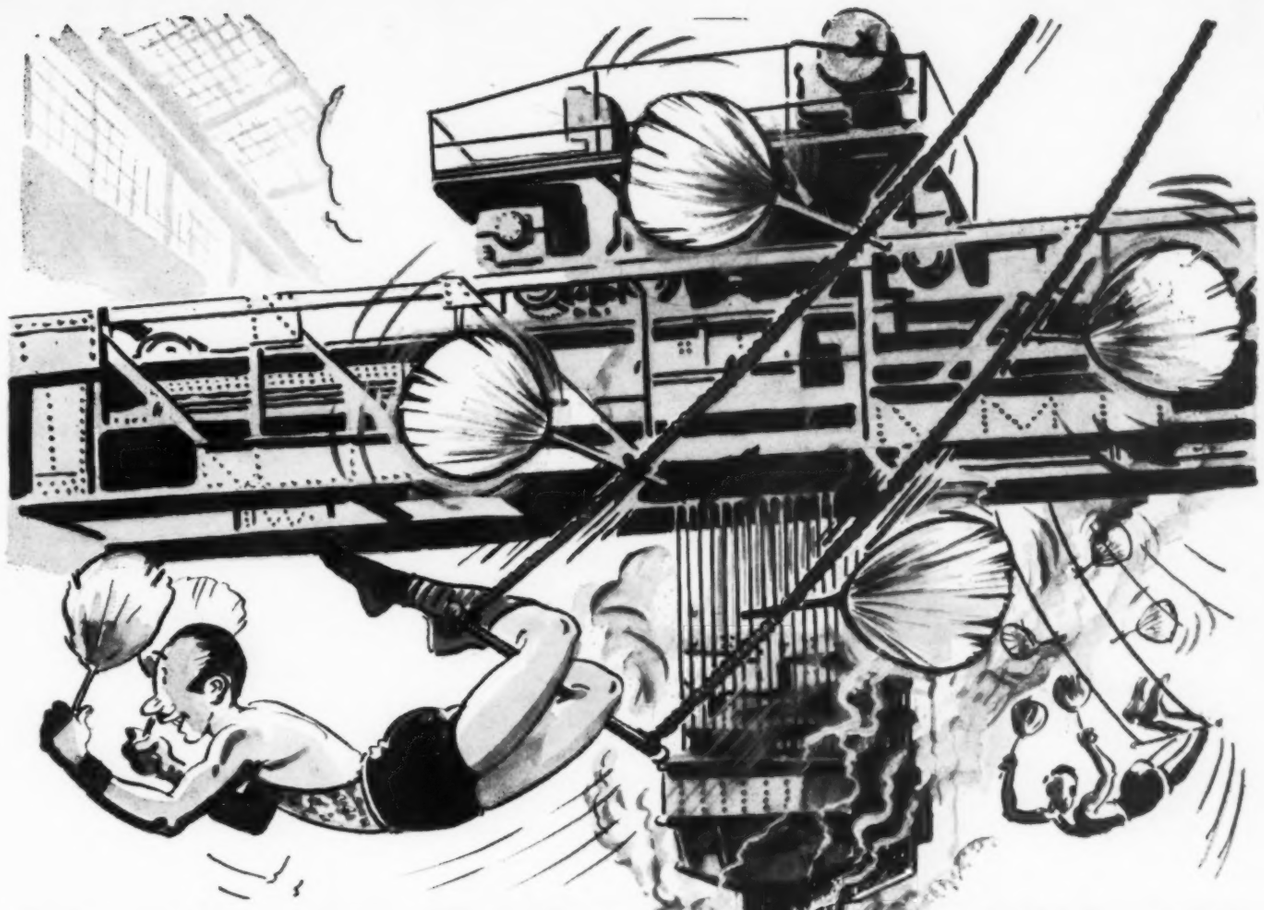
James A. Gates, general foreman at American Steel and Wire Company's central furnaces and docks has been appointed superintendent of that department. Mr. Gates was born in Steubenville, Ohio, and attended Carnegie Institute of Technology, receiving a bachelor of science degree in metallurgy before becoming associated with American Steel and Wire in July, 1925, as a

(Please turn to page 80)

C. H. MANION

WILLIAM L. BARR

CHARLES R. MILLER, JR.



HE SAILED THRU THE AIR

Rube Goldberg would give a high rating to this method of protecting the insulation of wires and cables against heat, but in Industry the smartest fellows are still the ones who use the simplest and most direct means to accomplish their desired purpose. And in cases like this one, the simplest method is to wire with Rockbestos . . *the wire with permanent insulation.*

Heat destroys ordinary insulation . . . dries it out . . . causes cracks, flaking and eventual failure and replacement. Nothing can be done, usually, about the heat . . . but you *can* do something about the wiring!

Next time you have to replace a heat-pulverized circuit use Rockbestos and you'll have a wire that was designed more than twenty years ago to do a real job of heat resisting for you. In those days it was made up with either a dense felted insulating wall of heatproof and fireproof asbestos, impregnated with an inert compound, or with the felted wall and a tough asbestos braid. Since then our patented feature of heat-sealing high dielectric moisture-resistant inserts between felted asbestos walls has greatly increased the scope of application. These wires were . . . and are . . . permanently proof against the ravages of heat, flame, oil, grease, moisture and corrosive fumes . . . and many of the early constructions are still doing business without replacement or attention.

Manufacturing heat resisting wires is our specialty. From the original wire we have developed over 100 standard constructions of wires, cables and cords. Literally, there is a Rockbestos wire of every size and type for every sort of severe service. Write today for our No. 10-E catalog and samples. Rockbestos Products Corporation, 966 Nicoll St., New Haven, Conn.

Also refer to the Electrical Contracting and Electrical World Buyer's Reference Editions

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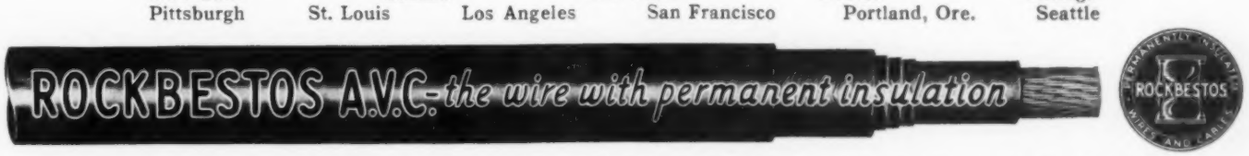


A typical construction—Table L, Rockbestos A. V. C. 600 volt Motor Lead and Apparatus Cable—One of 118 different heat resisting wires and cables.

LEROY R. BROOKS

SANFORD M. BROOKS

(Continued from page 78)

stock house foreman at central furnaces. He has served as general foreman since 1937.

J. C. Witherspoon, assistant general superintendent at American Steel and Wire Company's Donora Works, has been transferred to the steel division at Duluth, where he will be general superintendent. Mr. Witherspoon is a native of Pennsylvania, having been born in Belle Bridge. He joined the wire company in April, 1916, as second helper in the open hearth at Donora steel works. He held various positions before being appointed assistant general superintendent at Donora in May, 1938.

Harold Cope, superintendent of American Steel and Wire Company's blast furnaces at Donora, Pennsylvania, was appointed assistant general superintendent of the Donora plant. Born in Leechburg, Pennsylvania, Mr. Cope started working for American Steel and Wire Company in June, 1910, as blue print boy and tracer at the Donora steel works. He has worked in various positions with the company, having been made superintendent of blast furnaces at Donora in April, 1934.

H. O. Johnson, who has worked for the American Steel and Wire Company since 1910, succeeds Harold Cope as superintendent of the blast furnaces at Donora, Pennsylvania. Mr. Johnson was appointed general foreman of blast furnaces at Donora in March, 1937.

H. B. Burke, turn foreman at American Steel and Wire Company's Donora blast furnaces, will replace H. O. Johnson as general foreman of the blast furnaces. Mr. Burke started in 1909 with the wire company and was made foreman at Donora blast furnaces in 1926.

LeRoy R. Brooks has been elected secretary and sales manager of the Tool Steel Gear and Pinion Company, Cincinnati, Ohio. A graduate of Yale University, class of 1933, Mr. Brooks joined the gear company the fall of that year and spent some time in various departments of the plant. In 1934 he went to Chicago, working in the company's sales office at that point. Placed in charge of the sales of the Cincinnati and southern Ohio district in 1935, he divided his time in doing sales work and his duties as assistant to the president. Elected treasurer in January of this year, he held this position until his present appointment.

Sanford M. Brooks has been elected treasurer of the Tool Steel Gear and Pinion Company, Cincinnati, Ohio. He began work with this company in the fall of 1936, and spent two years working in the inspection, metallurgical and production departments prior to becoming assistant secretary of the company. In January, 1940, he was elected secretary and remained in this position until his recent appointment as treasurer.

J. N. Quinlan was made division superintendent of the west mills at Carnegie-Illinois Steel Corporation's Gary Works, after serving as assistant division superintendent of these mills since 1938. Mr. Quinlan began as a stores clerk in 1907.

H. H. Bushong, formerly superintendent of Carnegie-Illinois Steel Corporation's McDonald mills, Youngstown, Ohio, was transferred to Gary, Indiana, where he becomes first assistant division superintendent of the west mills. Mr. Bushong had been superintendent in Youngstown since 1935 and has held various positions in the corporation's Youngstown district operations.

S. R. Stanier was appointed second assistant division superintendent of the west mills, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Stanier went to the Gary Works from the Gary Sheet and Tin Division in 1936 as assistant superintendent of the merchant mill. Mr. Stanier was superintendent of the merchant mill strip mills at the time of his present appointment.

A. T. Greiner, who has been in charge of Salem Engineering Company's work in France, and **Thomas Breene,** who has been associated with Salem Engineering Company, Ltd., London, England, have recently returned to the United States. Both men are now actively associated with the sales department, working out of the company's home office at Salem, Ohio.

O. W. Baldwin has been appointed assistant chief chemist for the Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Baldwin was first employed at Gary Works as a blast furnace iron chemist in the chemical laboratory in 1925, and served there in various capacities until the present time. Mr. Baldwin was turn foreman at the time of his appointment.

Harry E. Reith, formerly with Brooks Oil Company, has been appointed special service representative for the Heppenstall Company, Pittsburgh, Pennsylvania. Mr. Reith served as master mechanic during the construction of Jones and Laughlin 96 in. continuous strip mill and prior to that was with Wheeling Steel Corporation in a similar capacity.

John A. Brown has retired from Heppenstall Company, Pittsburgh, Pennsylvania, where for the last ten years he was special service representative calling on the trade in the interest of the company's shear knife business.

Obituary

William A. James, veteran chief engineer of the Lackawanna Works of Bethlehem Steel Company, died recently at Chautauqua, New York. Mr. James was 69 years old, and was connected with the Lackawanna plant since 1901, when it was known as the Lackawanna Steel Company. He was a graduate of Lehigh University.

MATHEWS CONVEYERS

Helping Steel with its Biggest Job

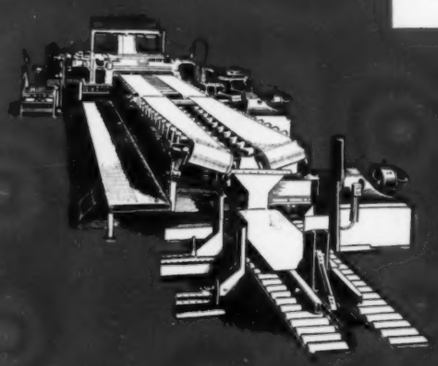
Side Tilter for discharging coils at right angles.

The plan for rearming America demands the rapid production of a vast amount of materials. A great share of the responsibility for this production has fallen to the Steel Industry. In fact, upon the ability of that industry to produce is hinged the success of this huge and vital armament program. Rightfully, then, Steel has been called "America's first line of defense."

The Mathews Conveyer Company, with greater facilities than ever before, is backing that line. Mathews engineers are working with Steel Plant engineers toward the application of conveying equipment which is designed to stand the coming months of severe service and abuse with a minimum of costly maintenance.

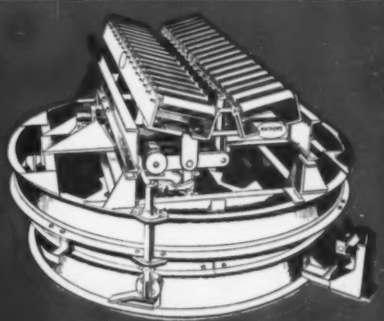
Mathews is glad for the opportunity to offer to the Steel Industry the experience gained from 35 years of engineering and manufacturing conveying equipment of high quality, and in this way help that industry to better serve the nation.

A Mathews engineer near your plant is eager to make your materials handling problem his own. We hope you will take advantage of his wide experience.



Belt Conveyer, troughed at end, for handling finished sheets from shear to piler.

Pallet Conveyer for handling hot or cold coils.



Power operated Turntable for changing the direction of coils as they move along conveyer line.

MATHEWS CONVEYER COMPANY

ELLWOOD CITY, PA.

PORT HOPE, ONT. SAN FRANCISCO, CALIF.

A BATTERY THAT SAVES TIME ON THE JOB *and* ON THE CHARGING LINE

EXIDE-IRONCLAD'S steel tray assembly packs more battery power—higher capacity, higher voltage—into the same space. Electrically speaking, you can install bigger batteries in the battery compartments of your trucks. You get more and faster handling of the heavy steel coils produced today. Exide-Ironclads get more done in less time.

They also save maintenance time. Not only are they rugged and trouble-free, able to take care of themselves, but the little attention they require is handled almost automatically by means of the Exide System.

The Exide System includes the Exide Discharge Indicator which protects you against delays and troublesome "tow-ins"—and provides the Exide Charge Control Unit which gives Exide-Ironclads the right charge at the correct rate, even cutting the circuit and signaling when the charge is complete.

There is only one control to set, and it takes fewer seconds than tuning a radio. Can you imagine battery maintenance much quicker and simpler than that? Write for new, free booklet, "The Exide System for Better Material Handling."

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